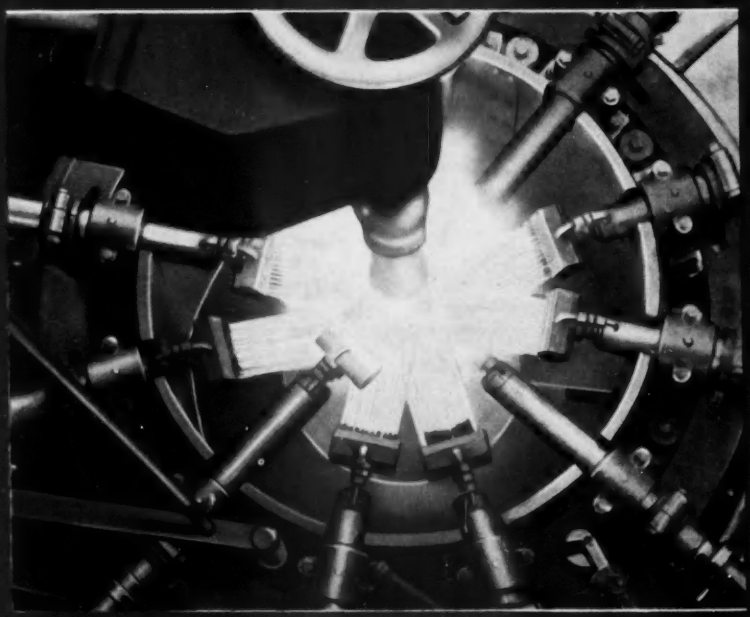
Vol. 15 No. 5 OCTOBER, 1952

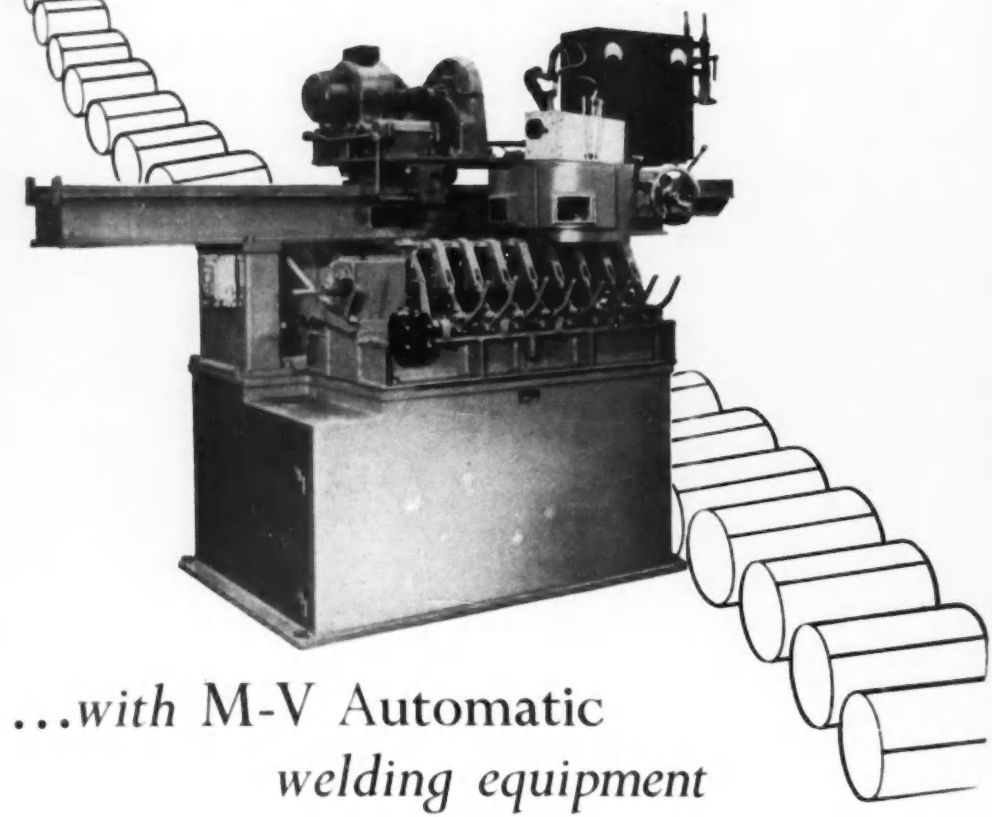
E DUOBUS UNUM

TRANSACTIONS OF THE INSTITUTE OF WELDING



(See Title Page)

Faster and Better Welding



...*with* M-V Automatic *welding equipment*

Remarkable increases in the speed of welding are made possible by Metrovick automatic equipment. It is simple to use, economical in operation and the higher rate of output means lower production costs. Metrovick make many types of welding equipment, and also electrodes for arc welding. In addition M-V have one of the biggest welding shops in the country, so that M-V offer not only an unrivalled range of equipment, but also a wide experience in practical welding. For advice on the best type of welding equipment for any purpose consult Metrovick, the makers who use the plant they sell.

1 Metrovick Automatic Atomic Hydrogen welding machine for cylinders with longitudinal welds.

METROPOLITAN-VICKERS ELECTRICAL CO. LTD., TRAFFORD PARK, MANCHESTER, 17.

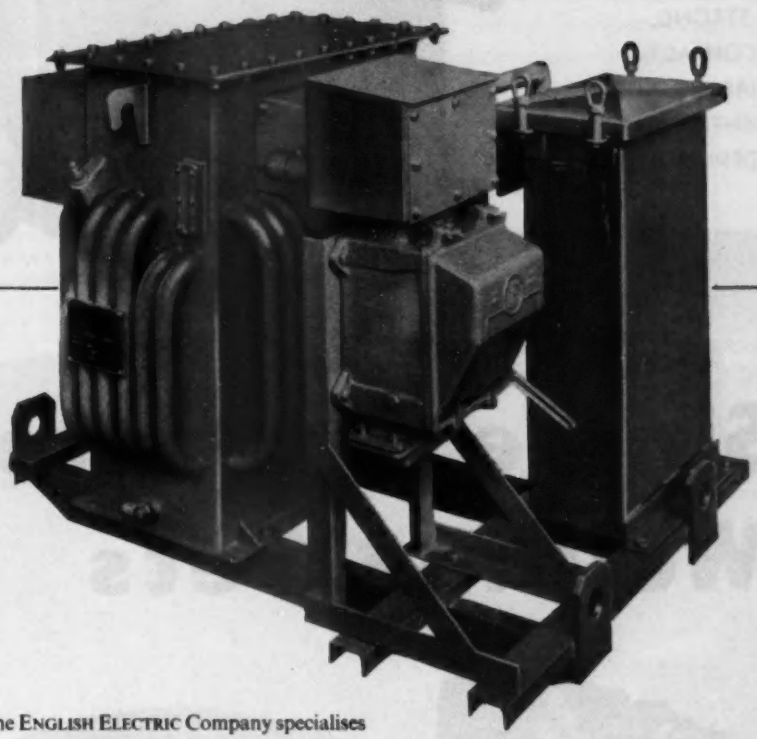
Member of the A.E.I. group of companies

METROVICK *Equipment for More Efficient Welding*

IE 005

'ENGLISH ELECTRIC'

multi-operator welding transformers



The ENGLISH ELECTRIC Company specialises in the design of multi-operator welding transformers which are made in various ratings to meet every industrial requirement. These, mounted on suitable underbase structures together with their associated capacitors and fuse switches, form robust compact units for use in heavy engineering workshops, giving ease of movement.

The illustration shows an underbase unit comprising a transformer type FWM. 300/3, a 16.5 kVA capacitor and a 150 amp triple-pole combination fuse switch.

THE ENGLISH ELECTRIC COMPANY LIMITED, QUEENS HOUSE, KINGSWAY, LONDON, W.C.2

Welding Equipment Section, Liverpool

WORKS: STAFFORD · PRESTON · RUGBY · BRADFORD · LIVERPOOL · ACCRINGTON

WE.5

STRONG,
COMPACT,
RELIABLE UNITS,
SCIENTIFICALLY
DESIGNED.

Single Operator Welding Sets

by G.E.C.

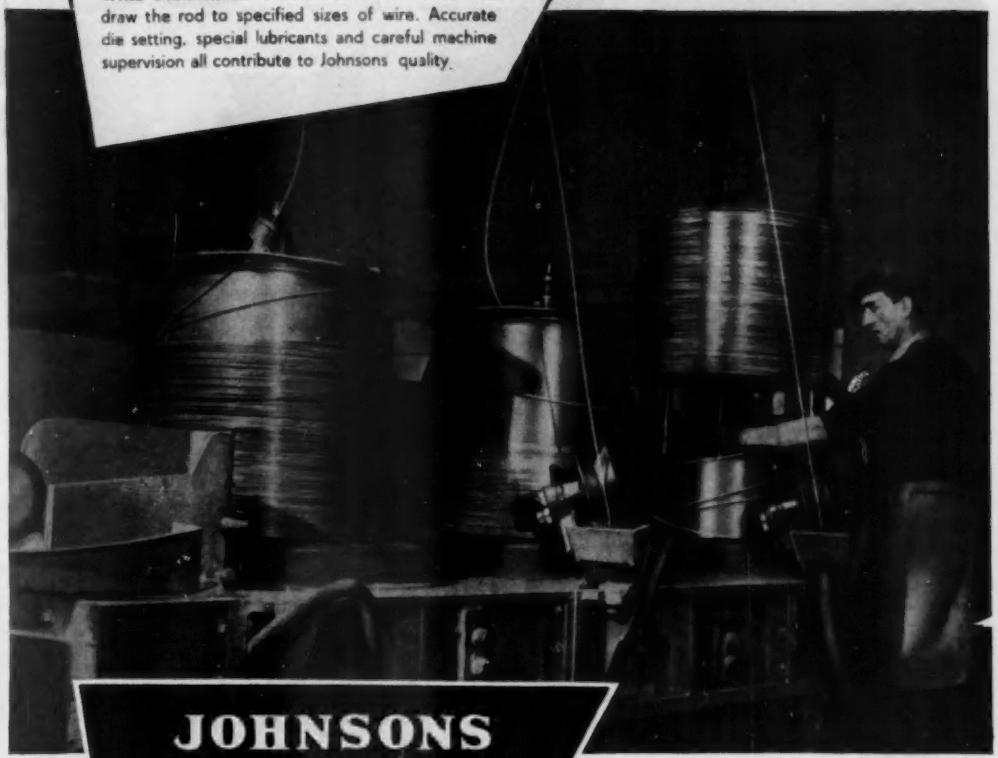
Send for Booklet P9556

THE GENERAL ELECTRIC CO., LTD., MAGNET HOUSE, KINGSWAY, LONDON, W.C.2

How much is your reputation worth?

It's worth just as much as the quality of the product you turn out! And for that reason it's wise to choose well when you buy welding wire. Make certain it comes from a firm with experience who really understand your needs. Then you are assured of a really first-class product correctly made to exact analytical requirements. In other words don't just buy welding wire . . . . . buy Johnsons!

WIRE DRAWING. Modern continuous machines draw the rod to specified sizes of wire. Accurate die setting, special lubricants and careful machine supervision all contribute to Johnsons quality.



JOHNSONS WIRE . . . *FOR THE WELDING INDUSTRY*

RICHARD JOHNSON & NEPHEW LTD., FORGE LANE, MANCHESTER, 11

Magnetic Crack Detection

Ask for leaflet ECD/52
describing the OK Magnetic Range of models designed especially for dealing with high speed testing of mass produced parts.

WELDING SUPPLIES LIMITED
Manufacturers of OK Electrodes at
BEECHINGS WAY . GILLINGHAM . KENT
Phone: Rainham (Kent) 81134 and 81600 Grams: Weldsuply Gillingham Kent

TRANSACTIONS OF THE
INSTITUTE OF WELDING

Vice-President: A. ROBERT JENKINS, J.P., A.I.Mech.E.

PRESIDENT - HOWARD J. THOMPSON, M.I.Mech.E.

Secretary: G. PARSLOE, M.A.

Honorary Editor: D. S. WATT, B.Sc., M.I.N.A.

VOL. 15 NO. 5 OCTOBER, 1952 PRICE 7s. 6d.

INSTITUTE NOTES AND NEWS

Gothenburg Meeting.—The International Institute of Welding held its fourth annual assembly at the beginning of September in Gothenburg. Some 450 members of the various Commissions attended and put in a week of strenuous and fruitful work, relieved by a number of splendid social functions arranged by the Swedish Reception Committee. The total British delegation numbered about thirty-five, led by Mr. C. S. Milne, the British Vice-President of the I.I.W. In the week following the meetings about 120 visitors went on to Stockholm and Malmo, from which centres a series of very interesting works visits took place. The organisation of the meeting was faultless and visitors were in general agreement that the meeting had been one of the most successful yet, thanks to the skilful arrangement of the programme by the Swedish hosts and the extreme care taken to ensure the smooth running of every function.

B.W.R.A. Conference.—The second B.W.R.A. Summer School, held at Ashorne Hill in July, was even more successful than the first. The programme fell into two parts, the first intended for welding-shop foremen, charge hands, welding operators and others concerned with practical aspects of welded fabrication, the second dealing with special aspects such as the metallurgy and physics of welding, testing and inspection, design and welding engineering.

A conference on Welding and Welding Research intended for management was held on the last Friday evening and Saturday and was very well attended. The proceedings consisted of four sessions on Research in Industry, the Achievements of Welding (two sessions) and Welding and Future Developments. The speakers at the first session, the Chairman of which was Sir William Larke, K.B.E., were the Earl of Halsbury, Sir Wallace Akers, C.B.E., F.R.S., Professor J. F. Baker, O.B.E., and Professor G. Wesley Austin, O.B.E. At the remaining sessions six prominent experts dealt with the achievements of welding in different fields of production and the possibilities awaiting its application in the fields of atomic energy and stratospheric flight.

Anglo-American Council on Productivity.—The Council, which has now been replaced by a British Productivity Council, has issued a final report, obtainable from 21, Tothill Street, London, S.W.1, price 3s. 6d. post free. The report surveys the work of the Anglo-American Council over its three-and-a-half years of existence and assesses the value to British industry of the work of the various productivity teams sponsored by the Council.

The Council has also issued *Electricity and Productivity*, a review of action taken on the report of the Electricity Supply Productivity Team, the sixth of a series of follow-up documents issued to the press, reviewing the results in British industry of the reports issued by the Teams.

FRONT COVER ILLUSTRATION.—Surface hardening steel machine parts is easily achieved by B.O.C. Flame Hardening. Shafts and tubes, all gear parts, former dies, press tools, shear blades, etc., are given the necessary hardness in exactly the areas required, and to a precisely controlled depth. There is no distortion and no sacrifice of toughness—for full shock-resistance is retained in the core. The illustration shows the B.O.C. 20" sectional ring burner, with built-in water quench, which can treat shafts and tubes from 5" to 20" in diameter, and in any length.

For full details of these cost-saving techniques write to:

THE BRITISH OXYGEN COMPANY LTD.,
LONDON AND BRANCHES.

PRINCIPAL CONTENTS

Institute Notes and News 127
Annual General Meeting 129
Book Review 130
Ingenious Repair by Welding 131
Institute Meetings 132
The High Speed Wind Tunnel at the Royal Aircraft Establishment, S. Farnborough 133
Latest Additions to the Library 144
Abstracts from Recent Welding Literature 145

Published by

THE INSTITUTE OF WELDING, 2, Buckingham Palace Gardens, London, S.W.1.

The TRANSACTIONS of the Institute are issued free to Members. To non-members the price of this issue is 7s. 6d. per copy (by post 8s.)

The Institute of Welding is not responsible for and does not necessarily endorse statements made by Authors of Papers and contributors to the Discussions thereon.

International Congress on Electro-Heat.—The President of the Institute, Mr. A. Robert Jenkins, has accepted an invitation to serve on the Comité de Patronage of the third International Congress on Electro-Heat, to be held in Paris from 18 to 23 May, 1953.

International Photographic Competition.—Le Centre Belgo-Luxembourgeois d'Information de l'Acier announces a second International Photographic Competition, offering prizes of 2,500, 1,500 and 1,000 Belgian francs for photographs of metal works of any kind, including structures, bridges, hangars, pylons and handling plant. The closing date for the submission of entries is 15 March, 1953. Further particulars may be had from the Secretary of the Institute.

Appointments Register.—Industrial Corporate Members may like to be reminded that a register of members seeking posts as foremen, supervisors, representatives, managers, designers, etc., is maintained at the offices of the Institute.

Employers seeking staff (other than welders) are cordially invited to inform the Secretary of the Institute of their requirements, and so assist the Institute to expand this valuable service to its members.

Offers of Papers.—Members of the Institute who are willing to read papers at meetings of the Institute or of its Branches are invited to send particulars to the Secretary for submission to the Programme and Journal Committee not later than 5 December next. Where the complete text of the paper is not available, a short synopsis should be sent.

List of Films.—The first edition of the Institute's list of welding films has been exhausted and a new edition, incorporating several additional films, is now available, price 1s. 6d. (to non-members 2s. 6d.). The list contains the exhibition details and brief synopses of 81 films, which are classified under thirteen subject headings. A simple reference system enables one to find the name and address of the suppliers of each film.

Handbook for Welded Structural Steelwork.—The Structural Welding Sub-Committee, which has charge of the new edition of the Handbook, met to consider suggestions of members and others toward the end of May. It is not, however, too late for those who wish to propose changes, improvements and additions, to send them to the Secretary of the Institute.

In the meantime, copies of the fourth revised edition are still available, price 10s. 6d. per copy, post free. This edition incorporates a number of important corrections to the formulae on pages 111-118 of the fourth edition. Members who have the original fourth edition are invited to apply to the Secretary for copies of the corrected pages, which will be supplied post free.

Binding of Transactions.—Arrangements have been made for the binding of members' volumes of *Transactions* in black embossed leathercloth at a cost of 10s. 6d. each, plus 1s. for postage and packing. Members wishing to take advantage of this arrangement should forward parts, with index, to Mansell (Bookbinders) Ltd., 41, Britannia Row, Essex Road, London, N.1.

Index to Transactions.—The index to Volume 14 (1951) of *Transactions* was published and bound in with the April, 1952, issue.

OBITUARY

MR. C. CYRIL HALL

Mr. C. Cyril Hall, whose death we announced in our August issue, was a past President of the Sheffield Branch of the Institute and its Chairman from the formation of the Branch in 1938 until ill-health compelled him to retire in 1945. Mr. Hall carried out the pioneer work on the welding of the first stainless steel suitable for welding, which was made in the Brown and Firth laboratories in 1924. As the 18/8 stainless steel was first used commercially in this country, Mr. Hall was in fact a world pioneer in its welding and read many papers on the fabrication of corrosion- and heat-resisting steels, including what is believed to be the earliest paper on the subject, delivered to the Institution of Welding Engineers in December, 1930.

Mr. Hall took a keen interest in the affairs of the Institute, first at Leeds and afterwards at Sheffield, where he was mainly responsible for the formation of the Branch. He was a man of a strong and likeable personality and his early death, at the age of fifty-six, will be lamented by a host of friends both within and outside the Institute.

We regret to record the death of the following members of the Institute: J. T. Bruce (Associate), Liverpool Branch; E. H. Davies (Associate Member), Preston Branch; R. Downs (Associate Member), South Wales Branch; E. Y. Felton (Associate Member), Preston Branch; A. Griffith (Member), Liverpool Branch; W. T. Jones (Associate Member), South Wales Branch; G. A. M. Lockyer (Associate), Liverpool Branch; C. S. McNeil (Member), Unattached; R. S. Tron (Associate Member), N.E. Tyneside Branch; E. Wilson (Member), North London Branch; J. K. Woolard (Member), North London Branch.

South Western Branch

There is little to report from most of the Branches in the way of summer activities. The South Western Branch has been honoured by the award of the O.B.E. to its former President, Mr. James Carr. It has also held a successful summer meeting, when a party spent an enjoyable day as the guests of Richard Thomas & Baldwin Ltd., at their Ebbw Vale steelworks.

The Branch held its annual dinner at the Hawthorns Hotel, Bristol, on 26 September, when some 70 members and guests assembled under the Chairmanship of Mr. A. W. Wall, Branch Chairman. The speakers after the dinner were the President of the Branch, Mr. A. J. Francis, who proposed the toast of the Institute of Welding, to which the President of the Institute replied. The Secretary of the Institute proposed the toast of the Branch and this was responded to by the Branch Chairman. Mr. James Carr, in proposing the toast of the Visitors, gave an amusing account of some of his experiences in the nationalised gas industry. Professor J. L. M. Morrison replied on behalf of the Guests.

ANNUAL GENERAL MEETING

The twenty-ninth Annual General Meeting of the Institute was held at the Institution of Civil Engineers on 22 July last.

Mr. Howard J. Thompson, retiring President, was in the Chair and presented the report of the Council in the following speech:—

"It is a satisfaction to me to be able to present to you, at the end of a year which has not been without its difficulties, the satisfactory report which lies before you. The Institute has had a good year.

"Probably the Honorary Treasurer, Mr. Harriss, will have something to say to you about our finances, but I would like to draw your attention to one or two outstanding features in the accounts. Our ordinary income increased last year by roughly £400 but the whole of this was absorbed by rising costs of administration, in which the main item was an increase of £330 spent on printing and stationery, explained in its turn by the abnormally high price of paper.

"So we ended the year with almost exactly the same surplus of income over expenditure as in 1950/51. That surplus is still uncomfortably small but it is a surplus, not a deficit, and that is cause for satisfaction in days of rising costs. I think that in the future we shall have to give attention to seeing whether we can increase our income.

"I am glad that during my Presidency your Council felt able at last to establish a contributory pension scheme for some of the Institute's employees. All good employers try to make such provision for their staff and the Institute ought to be as good an employer as it can afford. Moreover, the Institute ought to be insured against the risk of being faced with moral obligations which it could not discharge except at a crippling cost.

"You will see that the Working Reserve Fund has grown and is still growing, though modestly. I think members ought to congratulate themselves on the benefits which this Fund has already brought to the Institute, enabling the Council to seize the opportunity of acquiring the lease of our headquarters premises until 1990 and to make the premises more convenient for our use and more presentable—something of which a member need not feel ashamed, when he visits it in the company of a non-member. But this is only the beginning: the Fund will help to finance improved publications—a reprint of our excellent Handbook for Welded Structural Steelwork for example, and at least part of the production cost of the Handbook for Welded Design, the compilation of which is now going forward so quickly, under the care of Dr. Paterson.

"The Council has created a Lease Redemption Fund and the sales income from the publications will put back some at least of the money advanced from the Working Reserve Fund. So, as its name implies, the Fund is working capital, and every contributor to it can justly feel that he is helping the Institute to do things which raise its prestige and benefit British welding at large, things which it would be impossible for the Council to undertake without such a Fund.

"I wish there were enough money in the Fund to finance a real improvement in our *Transactions*. Your Council has always aimed at a monthly journal and at steady improvement both in technical quality and in presentation. These improvements would probably pay for themselves in time by attracting increased revenue but so far we have always been prevented from undertaking them by the initial expense involved. Much of this year discussions have been going on with the British Welding Research Association about this problem, because we are both convinced that the ideal solution is a united journal for the two bodies. I am afraid we have not yet found the way to do it, but we are still trying. I sincerely trust the way will be found. The main thing is that we should produce an efficient and good journal, which could go every month to every company which is working in metals. It may be possible to make some arrangement with the British Welding Research Association, but if not, I think we must tackle it along other lines and accept the risk.

"Outstanding functions of the year were, of course, the International Welding Congress and the Jubilee Meeting of the British Acetylene Association last July. The success of these two international meetings, for which the Institute shouldered the main responsibility, has undoubtedly brought great credit and much goodwill to us. There have been many expressions of appreciation, particularly from our overseas visitors. Members will have seen in the *Transactions* the full report of the proceedings at the Congress and they will be able to judge for themselves the progress which the International Institute is making and the value of our Institute's contribution toward it. If we are to talk in terms of cash at all, I may mention that the net cost of our co-operation in the work of the International Institute was this year lower than in the year before, although the direct subscription was a little higher. The net cost this year was only £270. When it is remembered that the French Institute of Welding last year contributed over £1,800 to make good the deficit on the publication of the Bibliographical Bulletin for Welding, and that that publication, with its thousands of abstracts of welding articles from all over the world, is freely available to our members in our library, I think it must be admitted that the expenditure we incur in asking our librarian to undertake the abstracting of British articles for the Bulletin yields a very handsome dividend indeed.

"The increase in our total membership probably reflects in part the interest and goodwill arising from the Congress and the attendant publicity. We should be wise not to be over-optimistic, however, because the flow of applications has again fallen back this year to the level of 1950.

"During much of the year the Membership Committee and the Education Committee have been engaged in a careful survey of the working of our membership regulations and our examination scheme, now a little over five years old. It is a notable achievement that in March, 1952, our total membership was only 34 below the peak level of 6 years ago, in spite of our having instituted an examination and raised the standards of qualification all round, and also—alas—though to a very modest extent, the subscription rates. But your Council is not content. Like others, we want both to eat our cake and have it and we are trying, through the appropriate Committees, to find how to keep the improved status achieved in the last few years, while at the same time accepting within the Institute as many as possible of those who want to join us but are not prepared to meet our requirements for the technical classes of membership. During the year I have written to hundreds of firms about the importance of bringing their welders and technical staff into the Institute, suggesting that the companies should pay the subscriptions where necessary. I think this is something which we should endeavour to develop, because it is through increased membership that we shall mainly make progress.

"I cannot conclude this summary survey without offering my thanks publicly to the members of the Council and its Committees, whose loyal support has always been forthcoming to me during my year as President, and also to the Officers and Committees of all our Branches. I have tried to show my own appreciation of their efforts by visiting as many as possible of them during the year. It is sometimes said to us that the money which we spend on the Branches would be better applied in improving the Institute's *Transactions*. Well, your Council has since the war deliberately aimed at increasing the number of the Branches, trying to ensure that every member in these islands was as far as possible within reasonable reach of a monthly meeting. We do not overlook the limitations which this policy involves but we believe that there is a sub-

stantial section of our membership which profits more from taking part in a lively discussion than by reading papers, however learned, however well presented, in a journal.

"The Branch Committees do a tremendous amount of unpaid work. Like the Committees at headquarters, they have constantly to try to make a little money go further than it reasonably could. Your Council think that they deserve the gratitude and support of all members who wish the Institute well. I should like to express my sincere thanks to Mr. Parsloe and his staff for their work for the Institute and for the International Institute.

"With these few words, I have pleasure in moving the adoption of the annual report with the statement of accounts for 1951/52 and I would ask Mr. Harriss to be good enough to second this."

The motion for the adoption of the report and accounts was seconded by the Honorary Treasurer, Mr. W. E. Harriss, and carried unanimously.

After the appointment of auditors, the Secretary reported that a letter had been received that morning from Mr. Rowland Harman regarding the *Transactions* of the Institute. The letter, which was then read, explained that the writer was unable to attend the meeting but wished to sound the opinion of members on the need for a drastic improvement in the *Transactions*.

The Chairman said that much careful thought had been given to this problem in the previous year, when he had entered into discussions with Sir Charles Lillicrap and Dr. Taylor, in the hope of finding some means of co-operation between the Institute and the British Welding Research Association in respect of publications. These discussions were still going forward and he was convinced that the Institute would have to take the financial risk involved in improving the journal, which would probably result in increased revenue later on. Mr. G. M. Boyd said that what Mr. Harman had put on paper was in the minds of many members. He was glad to note that the Council was in general agreement with Mr. Harman and was devoting attention to the problem.

After the Secretary had announced the results of the elections for Council, the Chairman invited the President Elect, Mr. A. Robert Jenkins, to take the Chair, after investing him with the chain of office. Mr. Jenkins, from the Chair, offered thanks for his election and intimated that it would be his wish to do everything he could to push forward the policies which his predecessor had explained and bring them to a successful conclusion.

Mr. Jenkins then spoke in terms of warm appreciation of the work which Mr. Thompson had done as President and asked him to accept a photograph of himself. With this presentation the proceedings ended.

BOOK REVIEW

Electric Arc and Oxy-Acetylene Welding, a Practical Handbook for Works Managers, Welding Operators and Students. By the late E. ARTHUR ATKINS and A. G. WALKER. Revised by W. A. ATKINS and A. G. WALKER. Fourth Edition, pp. xi+352, illustrated. (Pitman, 1952, 30s.)

"Atkins and Walker's Welding Bible," to give it its time-honoured name, is the oldest established text-book of its type in the English language, and has always been regarded as a serious contribution to the literature of welding. It is, therefore, all the more regrettable to have to record that this latest edition is, in many ways, a source of disappointment. In view of the fact that it is sixteen years since the appearance of the last edition, it is a great pity that more care was not taken to bring the contents up to date. The proper application of modern design methods for welding is considered to be of such paramount importance that leading welding engineers in this country have been engaged for some time in the preparation of a reference book on the subject. In Chapter II of the book under review, under the heading "Essential Points for the Production of Good Welds," no mention is made of the vital necessity for ensuring good design of the job to be welded. The five points which are enumerated, viz. Operator's skill, machine efficiency, base material, quality of electrode and, electrode coating, do not afford any comfort to a welder who, owing to inadequate thought on the part of the designer, cannot even reach the joint to be welded.

The jointing of successive lengths of welding cable by means of bolts and nuts, recommended in Chapter III, is inadvisable on many counts; most shop, shipyard and site welders have long since discontinued this unsatisfactory practice. The use of small lengths of copper tubing suitably flattened and taped ensures a much more lasting joint and is now quite common practice. It is generally conceded that arc blow is an important factor to be considered when using direct current equipment, and this was, incidentally, one of the major reasons for the wholesale introduction of alternating current transformers during the last war; even so, more attention ought to have been given to the subject than the meagre seven words allotted to it.

The repeated use of the word "goggles" in Chapter V, when referring to the important subject of eye-protection in electric arc welding, is to be deplored; the conclusion to be drawn therefrom is that goggles afford sufficient protection. It cannot be too strongly emphasised that the proper employment of welding screens or welding helmets (the latter are not mentioned) is essential in all forms of arc welding or cutting.

The recommendation to "crack electrodes in the middle," implied in one of the illustrations, is anachronistic; the practice of bending electrodes in the middle has, for very good reasons, always been frowned upon by manufacturers and users alike. It is conceded that the hammering, or "peening," of welds may have certain benefits in limited cases, but this practice could not be economically carried out to the extent recommended by the authors. Power factor, and its correction, are very important financial considerations for the user of alternating current welding equipment no less than for the power supply authorities, and much more could have been written on the subject than the meagre formula given in Chapter XVIII. The "Suggested Procedure" tables in Chapter XIX bear little relation to current practice; for instance, a $\frac{1}{4}$ in. fillet is recommended to be made with no less than nine runs with 8 s.w.g. electrodes. The 1951 *British Standards Year Book* lists 30 standards on the subject of welding; it is, therefore, a disappointment to find that the only two mentioned in the book are twenty-nine years old. Dealing with the Progress of Welding, no mention is made of the rapidly increasing use of automatic and semi-automatic devices; no place is found for the inclusion of even a small paragraph on the universally used low-hydrogen electrodes, inert gas welding, and the latest methods of weld testing by ultra-sonics. Finally, it may not be considered out of place to point out that the Institution of Welding Engineers, briefly mentioned on the last page of the book, changed its name to the Institute of Welding in 1935.

B. W. S.

INGENIOUS REPAIR BY WELDING

We print the following account of an interesting repair by welding, and take the opportunity to invite our readers to send us similar short notes on actual jobs done by them or under their supervision. Practical notes of this kind are of great interest to many of our readers, and members can assist the Institute by contributing them from time to time.

We have been favoured by Charles Bradbury and Son of Mossley, with the accompanying photographs of a cast iron wheel before and after repair by welding. The wheel is of a special type, weighing about 4 cwt. and approximately 4 ft. in diameter.

The following was the welding procedure used in the repair :—

A gauge was first made from the bore to the outside of the teeth to check the rim after each weld. All the welds were made from the inside, so as to avoid any sideways distortion of the rim.

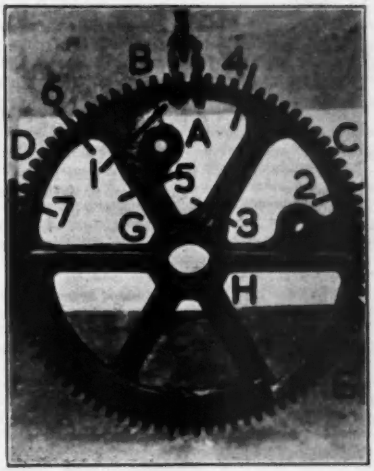


Fig. 1

Piece A was first welded to piece B at weld No. 1. Piece C was then clamped in position, after setting with the gauge, and welded at No. 2. The rim of this section was then sprung out with a jack, so as to make a gap between the rim and the boss, large enough to allow for expansion of the arm by heating before welding at No. 3 weld. The jack was removed and the work allowed to cool, the rim coming down exactly to gauge.

Piece B was then clamped on lightly and allowed to move round during heating and welding at No. 4; this was done to prevent the metal crushing during welding and altering the pitch of the teeth.

For weld No. 5 the rim of B was again jacked out, leaving a gap as before; the metal on each side was heated and the gap closed before welding. This weld was also allowed to cool and again checked.

The last piece D was now inserted and clamped to a curved plate on the outside of the teeth to hold it in position; both these fractures now fitted quite closely. As the wheel was now too strong to be sprung out, it was hung up from the rim at E and the boss heated at points G and H. This expanded the boss and so opened out a gap in the rim which was heated and welded at No. 6. After cooling, the boss was again heated, a gap made and weld No. 7 completed.

The rim was checked after cooling, found to be correct, and the pitch at each weld was also correct. The wheel was given a good hammering but there did not appear to be any strains left in it and it ran true in the lathe.

As each weld had to be allowed to cool before proceeding further, the total time taken was one week, which was considered good, as several months would have been required for delivery of a new wheel.

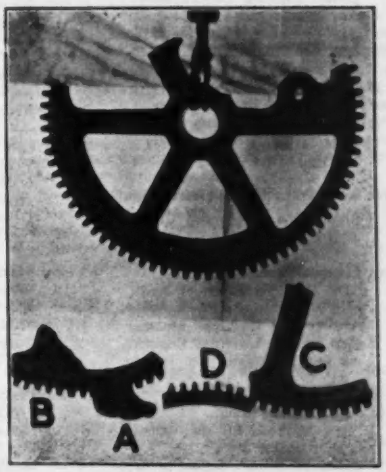


Fig. 2

INSTITUTE MEETINGS

NOVEMBER AND DECEMBER

The following is a list of meetings of the Institute and its Branches so far as details are available at the time of going to press:—

1 Nov. **Wolverhampton Branch**
Works visit to the Steel Mills of Stewart & Lloyds at Bilston.

5 Nov. **Manchester Branch**
Brains Trust; Reynolds Hall, College of Technology, Manchester, 7.15 p.m.

5 Nov. **Preston Branch**
"Recent Developments in Arc Welding Electrodes," by D. H. Young; Harris Technical College, Preston, 7 p.m.

6 Nov. **North Eastern (Tyneside) Branch**
Paper by Dr. H. Harris; The Mining Institute, Neville Hall, Newcastle, 7 p.m.

6 Nov. **North Eastern (Tees-side) Branch**
"Recent Developments in Welded Structures," by S. M. Reisser, B.Sc.(Eng.), A.M.I.C.E., M.I. Struct.E.

6 Nov. **Eastern Counties Branch**
"Fabricating for the Electrical Engineering Industry," by H. H. Reeve; Lecture Hall, Electric House, Ipswich.

10 Nov. **Sheffield Branch**
Film night.

11 Nov. **Leeds Branch**
"Recent Developments in Arc Welding Electrodes" (lecturer not given); Lighting Service Bureau, Aire Street, Leeds.

13 Nov. **Eastern Counties Branch**
To be arranged—at Cambridge.

13 Nov. **South London Branch**
"Site Welding," by A. Brewitt; 85-88, Minories, London, E.C.2., 6.30 p.m.

13 Nov. **South Wales Branch (West Wales)**
Brains Trust; Technical College, Swansea.

13 Nov. **Liverpool Branch**
"The Heat Treatment of Steels," by R. J. Brown, F.I.M. Combined meeting with Liverpool Metallurgical Society; Liverpool Engineering Society's rooms, The Temple, 7 p.m.

14 Nov. **East Midlands Branch**
"New Methods for the Welding of non-ferrous Metals," by J. F. Lancaster, B.Eng.; School of Arts and Crafts, Derby, 7.15 p.m.

14 Nov. **Birmingham Branch**
"Practical Welding," by E. Storey.

14 Nov. **South Western Branch**
Visit of members of the Welding Productivity Team to discuss experiences in the U.S.A.; Radiant House, Colston Street (Pipe Lane), Bristol, 7 p.m.

19 Nov. **North London Branch**
"Recent Developments in Arc Welding Electrodes," by D. H. Young; Technical College, Enfield, 7 for 7.30 p.m.

19 Nov. **Wolverhampton Branch**
"Protection of the Eyes," by — Cooper.

19 Nov. **West of Scotland Branch**
"Automatic Welding," by J. Latimer.

21 Nov. **East of Scotland Branch**
"Automatic Welding," by J. Latimer; 25, Charlotte Square, Edinburgh, 7.30 p.m.

24 Nov. **South Wales Branch (East Wales)**
"Future Developments in Shipbuilding," by J. W. Day; South Wales Institute of Engineers, Park Place, Cardiff.

27 Nov. **South Western Branch**
"Welded Tubular Structures," by E. McMinn, with film on the world's largest dragline boom at Corby, Lincs; Works Canteen of Stothert & Pitt Ltd., Bath, 7.15 p.m.

27 Nov. **Medway Section**
Chairman's Address by L. A. Lidston, M.S.E., followed by films on manipulators for welding and design for arc welding structures; Sun Hotel, Chatham, 7.15 p.m.

28 Nov. **North London Branch**
Branch dinner at the Holborn Restaurant, W.C.1.

2 Dec. **East Midlands Branch**
"The non-destructive Examination of Welding by Gamma-Rays and other Methods, including practical Demonstration"; Victoria Station Hotel, Nottingham, 7.15 p.m.

3 Dec. **Manchester Branch**
"Recent Developments in Resistance Welding," by H. E. Dixon, M.Sc., A.I.M.; Reynolds Hall, College of Technology, Manchester, 7.15 p.m.

3 Dec. **Preston Branch**
"Architectural Metal Works, Agricultural Implement and Production Welding," by C. Spencer; Harris Technical College, Preston, 7 p.m.

4 Dec. **North London Branch**
"Some Applications of Resistance Welding in the Automobile Industry," by G. H. C. Moss, with films; Regent Street Polytechnic, W.1, 7 for 7.30 p.m.

4 Dec. **North Eastern (Tyneside) Branch**
Lecture by Dr. R. Weck; The Mining Institute, Neville Hall, Newcastle, 7 p.m.

4 Dec. **Birmingham Branch**
Annual Dinner

4 Dec. **Eastern Counties Branch**
"The Abbey Steel Works," by W. S. Atkins, B.Sc., M.I.C.E.; Room 17, Norwich City College and Art School, St. George Street, Norwich.

5 Dec. **Eastern Counties Branch**
To be arranged—at The Liberal Club, Headgate, Colchester.

8 Dec. **Sheffield Branch**
"Modern Developments in Electric Welding," by Dr. H. G. Taylor, D.I.C., M.I.E.E.; Joint meeting with the Sheffield Section of the Institute of Production Engineers.

9 Dec. **Liverpool Branch**
"Welding of non-ferrous Metals," by F. A. Fox, D.Sc., F.I.M.; 9, Whitechapel, Liverpool, 7 p.m.

10 Dec. **INSTITUTE MEETING**
"Experiment on Welded Pressure Vessels and Pipe Line Components," by N. Gross, Ph.D., M.I.Mech.E.; Inst. of Civil Engineers, 6.30 p.m.

11 Dec. **South London Branch**
"Development of the Twin Arc Welding Process," by E. C. Davies, A.M.I.E.E.; 85-88, The Minories, E.C.2, 6.30 p.m.

12 Dec. **Birmingham Branch**
"Argonarc Welding," by K. Purdy.

12 Dec. **South Western Branch**
"Welding Pressure Vessels," by Dr. H. Harris, B.Sc., D.I.C.; Radiant House, Colston Street (Pipe Lane), Bristol, 7 p.m.

12 Dec. **East of Scotland Branch**
Open Forum; 25 Charlotte Square, Edinburgh, 7.30 p.m.

17 Dec. **Wolverhampton Branch**
"Applications of Jigs and Fixtures in the Welding Industry," by H. H. Reeve.

17 Dec. **West of Scotland Branch**
"Organising for Welding," by D. M. Kerr, A.M.I.M.

18 Dec. **Leeds Branch**
Discussion Night; Lighting Service Bureau, Aire Street, Leeds.

THE HIGH SPEED WIND TUNNEL AT THE ROYAL AIRCRAFT ESTABLISHMENT, S. FARNBOROUGH

(With special reference to welding, shop assembly and site erection)

By J. H. BELL*

A paper read at the Spring Meeting, Glasgow, 1952

THE subject of this paper is the high speed wind tunnel constructed for the Air Ministry at their Experimental Station at Farnborough, in Hampshire.

For security reasons the writer has refrained from making reference to speeds and performances subsequently attained during the working of the structure.

The project first came under consideration about July, 1938; the contract was received at the end of that year and detailing in the drawing offices began during the early part of 1939.

The wind tunnel was officially opened in November, 1942, and was in full running order the following year. It was considered the finest of its type in the world, since the maximum velocity of the airstream through the working section could be maintained for a considerable period, as compared with a somewhat similar type of tunnel in America, in the working section of which, according to reports, the maximum velocity can only be retained for a few seconds.

It will be realised that an early completion of the tunnel structure at site was essential if it were to take its proper part in the initial stages of the production of fighter aircraft, so greatly in demand at that time, and so essential to the near approach of our invasion of the Continent. This state of affairs had a direct bearing on our procedure for the workshop erection of the structure and subsequent site erection, deviations of organisation being very necessary in the former programme, since war broke out before this had made much progress.

As with many contracts, constructional procedures, especially in welding, continue to progress and vary year by year and this contract is no exception. It is now twelve years since the tunnel was detailed and the firm's welding experience has travelled far in the intervening period. It must also be appreciated that to some extent, as far as the company was concerned, welding construction and experience were in their infancy and only developed extensively during the war period. Consequently if, during the reading of the paper, certain welding constructions and procedures appear perhaps a little dated, the answer is obvious. Nevertheless, the wide experience gained during the building of this unique structure would form a fine background for any erection of a similar nature.

A point worthy of mention might be certain site joints which, had our welding technique been as far advanced as it is to-day, could undoubtedly have been made by site welding in lieu of fitted bolts with lead washers to provide air seals. These are, in general, the circumferential and longitudinal site joints on the outer shell and possibly the site joints in the circumferential joist beams. A large percentage of overhead and vertically up site welding would have been employed, but these provide no great difficulties to the experienced welder to-day, assuming that correct preparations and welding procedures are employed, and would possibly pay dividends in the long run.

The general outline of the tunnel structure is as shown in Fig. 1. It consists essentially of an outer shell, cylindrical in shape with hemispherical ends; within this shell is a second structure known as the inner shell, also cylindrical in shape but of a conical nature, the diameter at one end being 6 ft. 6 in. greater than at the other; this second shell has a hollow core running from end to end and the parts of this passage are known as the contraction cone, working section, expansion cone and fan section respectively. The inner shell is supported from the outer shell by means of two sets of cast aerofoils (6 castings in each set), one set at either end of the structure; the hollow core is in turn supported from the inner shell by bracings. It is between these passages that the air stream is circulated by a fan situated in the fan section, and models, etc., for testing, are suspended in the working section.

In order that the maximum working speed might be attained within the tunnel with a reasonable expenditure of power, it was necessary to evacuate most of the air and run under conditions of reduced density, the latter being about one-tenth atmospheric. In these circumstances the outer shell had to be a strength shell and as airtight as practicable, hence its cylindrical shape with hemispherical ends. The horse-power required to circulate the air in these conditions is mainly used in overcoming the friction of the walls, and the energy reappears in the form of heat; consequently some form of cooling system was required.

In this direction the subsequent solution of combining the cooling jacketing and strength systems was attributed to the late Mr. John Thomson. This was a surprisingly simple construction but one which gave every satisfaction. Channel sections 12 in. × 4 in. were welded toe on to the outer surface of the shell about 10½ in. apart; these sections being later bridged by plates lapped to their heels. This gave the shell a theoretical thickness of about 4½ in., with a factor of safety of 5, able to withstand collapse up to a pressure of about 67 lbs./sq.in. This method of construction, in addition to its strength, also provided a system through which a cooling liquid might be circulated. The entire scheme was accepted without questioning by the designers of the tunnel and a similar scheme was applied to the inner shell and expansion cone. These sections, however, although requiring a cooling jacket, strong enough to withstand slight variations in pressure which would possibly occur from rise and fall in wind velocity, did not require a strength shell in the same proportion as the outer shell.

The method of workshop erection for the various shells is dealt with in the paper under their own headings. It is interesting to record, however, that prior to commencing the fabrication in our structural shops, the roof of our erecting shop was raised about 25 ft. specifically for this contract and an additional 10-ton electric overhead crane built at a sufficiently high level to clear the tunnel when fully built. Because of the outbreak of the war and the urgency for the structure to be completed at site, it was never assembled as a complete unit in our workshops. Every section, nevertheless, was in one form or another fitted to its adjacent part, with the result that few difficulties arose during the final assembly at Farnborough.

The method of testing, as far as our part of the contract was concerned, was that the structure should successfully withstand an internal pressure of 45 lb./sq.in. absolute; and that the air within the shell be evacuated till the pressure was about one-tenth atmospheric (1·5 lb./sq.in). Our only method of searching for possible leakages was to raise the pressure within the tunnel to between 45 and 50 lb./sq.in. and make a thorough search of the outer shell, using soapy water at all joints and bolts. The entire shell was eventually covered in this manner and any weak points caulked or given a sealing run of weld.

We were given a specific target at which to aim; generally, that the internal pressure should not drop more than about 5 lb./sq.in. from its maximum over the first two-hour period, and about 2 lb./sq.in. over the third hour. This was successfully achieved, as shown by the graph in the paper.

THE HIGH SPEED WIND TUNNEL—WORKSHOP CONSTRUCTION

Outer or Strength Shell

The outer shell, as mentioned in the Introduction, was the strength shell and consisted essentially of a cylinder of 37 ft. inside diameter, 96 ft. long with two hemispherical ends. This shell was supported at only two points by means of circular box-shaped girders, which in turn transmitted the dead load to four foundation feet resting on concrete plinths.

The cylindrical portion was divided longitudinally into strakes of plating 11 in number, about 8 ft. 10 in. broad; these plates were

* Sir Wm. Arrol & Co. Ltd.

again divided circumferentially, six plates forming the circle (Fig. 1).

It was along the inner face of this shell that the air-stream must pass at a high velocity and consequently, if oscillations in the air-stream were to be reduced to a minimum, it was essential that the finished surfaces should be as smooth as possible and free from corrugations.

The first operation was to remove all rust and scale; to do this the plates were treated in a pickling tank of hydrochloric acid prior to being rolled to the required radius; the latter process assisted this operation by expanding and contracting the extreme fibres of the plate. The channel sections and flats, which were subsequently to form the cooling circuit and strength members of these plates, were similarly treated. It was important that as much scale, etc., as possible be removed from all material forming the cooling jacketing, since matter of this nature might gather in time and block the brine circulation, brine at about 0 deg. C. being the cooling liquid.

The setting to radius of the channels and flats was carried out by a cold process in a horizontal press, specially shaped male and female blocks being made for this operation (Figs. 2, 3 and 4).

Fig. 2 shows the general assembly of channels and flats to the shell plating to form a cooling circuit and strength reinforcement. Figs. 3 and 4 illustrate the method adopted to fabricate the channels and joggled flats. Extreme care had to be exercised during the former operation to ensure that the flanges of the channels remained square to the web, since there is a tendency during this type of operation for the flanges to warp, especially when channel sections are curved in the fashion shown, *i.e.* toes in. Any fluctuation of the toes would have been detrimental to the fit of the channels to the plates and at the same time would certainly not have provided a good junction for fillet welding. In the fabrication of the joggled plates the main object was to ensure that the joggles were formed in the proper place.

The next operation was to provide jigs for the assembly and welding of the outer shell plates; these were built as shown in Fig. 5, and consisted essentially of a joist grillage base, on which were erected four ½-in. thick ribs, stiffened at the curved edge by light channel sections. On being welded together, the jigs were then balanced on trunnion bearings, this being a desirable feature by providing downhand welding positions throughout the welding of the shell plating. The design of the shell called for 5/16 in. welds on channels and joggled flats. The former were welded first, and to provide balanced welding after tack welding in position, two welders worked simultaneously on either side of a channel, working from the centre of the channel towards its end in every case; in addition the inner channels were completed first, followed by the outer pair. Similar welding procedure was adopted for the welding of the joggled plates to the channels, and for the welding of the end flats which sealed up the circulating system.

Our clients had continually stressed the importance of the finished air-stream surface being smooth and free from corrugations, especially any which might be contrary to the direction of flow. Actually the limits of roughness specified were 0·001 in. to 0·003 in., but this turned out to be more theoretical than practical, despite the fact that excessive care was exercised at all times. Nevertheless, at this stage in construction, it was considered necessary to try and anticipate the distorting and contracting effects that 250 lineal feet of weld were likely to have on a 9/16 in. thick plate, 8 ft. 10 in. wide by 19 ft. 4½ in. long, all deposited on one face.

We had little or no experience to guide us in this matter, but in order to arrive at some figure, a few small tests were made on miniature curved plates. We eventually arrived at a figure and it was decided to set the full-sized plates as shown on Fig. 6; that is, the inside radii of the plates were slightly decreased and at the same time an endeavour was made to "break" the plate a little in cross section. The figures worked to are as shown on sketch. The ½-in. thick ribs forming the jig had already been gas cut to this slightly reduced radius, and at the same time their depths had been varied to give a slight curvature in cross section. The plates were clamped to the jig, the channels first and the joggled plates later were set thereon, and the whole assembly was screwed down by means of adjustable cross beams and long holding-down bolts. The breaking effect was accomplished by adding jacking screws to the cross beams at the points where the channels and joggled plates occurred (Fig. 7). Production welding was then carried out between the channel toes and the shell plate, and the edges of the joggled plates to the channel webs. The 5/16 in. welds were laid in two runs, but prior to the second run being laid the first run in each case was "dollied" (or "peened") from end to end, working in each case from the centre of the plate to its extremities. Since the plates were too large to be annealed in a furnace, it was thought that this process of peening might have some effect of relieving the stresses which were likely to be locked up in the plate as a result of extensive welding and at the same time it would assist in producing watertight (or brine tight) welds.

Each plate, on being released from the jigs, was tested for curvature by a steel template, and on cross section by a steel straightedge. The results achieved showed that our jigs and welding procedures had been very satisfactory, each reinforced plate passing our clients' inspector without much difficulty.

Fig. 8 depicts diagrammatically the brine circulating system for one outer shell plate, a similar system being adopted on the inner shell plates and expansion cone plates. Holes were gas cut in the channel flanges as shown, thus allowing the brine to flow in the proper direction; the inlet and outlet holes in each plate were joined at site to its adjacent plate by means of U-shaped pipes. Prior to dispatch from our works, however, each reinforced plate was given an individual watertight test, the inlets and outlets being temporarily plugged.

Approximately 66 plates of this nature were constructed to form the outer or strength shell.

Circumferential Strength Beams on Outer Shell

On the outer shell each strake of plating was joined longitudinally to its adjacent plate by a double riveted buttstrap on one edge (shop rivets) and a double line of cheese-headed fitted bolts (site joint) on the other edge. Circumferentially, however, the strakes were joined by circular joist section beams built up to 14 in. × 8 in. as shown on Fig. 1.

As in the case of the shell plating, six sections of beam formed one complete circle, but from a strength point of view the joints in the shell were staggered with the joints in the circumferential beams (Fig. 10).

Fig. 9 shows an enlarged view of a section through a circumferential beam, showing also the method of site joining the shell plating, and the type of site bolt used. The method of making the site joints will be dealt with later.

The assembly, welding and fabricating of these circumferential beams proved interesting. The web was of 13 in. × ½-in. thick plating with an outer flange 8 in. × 1 in. and an inner flange of 12 in. × ¾ in., the latter being subsequently machined to about ⅝ in. thick.

The web plates were machine gas cut to shape from a large plate and the flange plates set to radii in the horizontal press, as in the case of the channels and joggled plates on the outer shell. Once again the possibility of weld distortion and contraction had to be taken into consideration and allowance made for same. Fig. 11 shows our allowances which later proved quite satisfactory. In addition to being curved, the flange plates were slightly backset, and when gas cutting the web plate, the radius was made slightly sharper, the subsequent production welding doing its duty by drawing these sections into the required set.

It was essential that the inner flange plate at least should be square to the web, since these were required to be machined later and remain as thick as possible, the "black thickness" being only ⅝ in. The squareness of the outer flange plate was not quite so critical, although this factor could not be neglected entirely, since at site each strake of beams was crossed at twelve points by ⅝ in. thick gussets, which joined up twelve lines of short longitudinal beams 10 in. × 6 in. × 40 in., the continuity of which provided the necessary longitudinal stiffening, since the structure was only supported at two points.

The jig formed for the assembly and welding of these beams was as shown on Fig. 12. Radial beams were set in concrete on the shop floor and levelled; inner jacking screws were fitted to these beams and intermediate clamps, composed of screwed rods and angles, were fitted to the beam assembly itself for holding in position during tack welding operations. The sharper radius, to counteract weld contraction, was given to the assembly by adjusting the jacking screws, and ⅝ in. fillet welds were laid between the web and flanges in the following sequence, in an endeavour to obtain balanced welding.

(1) Outer flange welded, for first run, from centre of beam towards extremities, two welders working simultaneously.

(2) Similar procedure adopted for welding of inner flange first run.
(3) Beam was released from jig, reversed, reclamped and similar procedure adopted for first-run welds as before.
(4) Each first run then given a light "dollying" or peening, working from the centre towards ends, as in the case of the outer shell plating; this was in an endeavour to relieve as much weld stress as possible.
(5) Similar procedure as before given to the second and last weld runs.

Prior to leaving the welding jig the beams were marked to length and given an approximate radial check to ensure at least a "clean-up" of the inner flange by the rotary plane. Our assumptions for weld contraction proved very successful, all beams passing our clients' inspector.

Approximately 78 beams were produced from this jig for setting up into circles.

The beams were then drilled on ends, tack holes drilled for webs and flange covers and despatched to the engineering shops; here they were set to a circle of 37 ft. on level blocks, clamped, all web and flange plates assembled with black bolts and barrel drifts, the inner flange machined for its full depth in the rotary plane to a true diameter, after which all joint holes were reamered out for fitted bolts. The whole assembly was then broken down (all beams being marked in their respective positions for re-assembly) and returned to the structural shops for further fitting.

The machining of the inner flange was twofold: firstly, to ensure a true diameter against which the shell plates would be fitted, since our tolerance on the 37 ft. dia. was $\pm\frac{1}{4}$ in.; secondly, to obtain a machined face against which two shell plate edges would be joined and avoid any tendency for one plate to be proud of the other, a joint of the latter type would provide an obstruction to the air-stream, and our tolerance in this direction was in the region of thousandths of an inch.

Shop Assembly of Outer Shell

As mentioned previously, the site assembly of shell plates to circumferential beams was by means of cheese-headed barrel bolts. So it was essential that all sections should be fitted and drilled in position in our workshops, thus expediting site erection. Unfortunately, circumstances did not permit the two shells being related in our workshops, so that other methods had to be used. The following procedure was adopted for the outer shell (Fig. 13).

(1) Shell strakes A, B and C were erected in a horizontal position, complete with their corresponding strength beams. Care was exercised to ensure that the latter beams were true in circumference and level; the shell plate holing having been drilled on the flat, the beam holing was drilled from the shells during this erection.
(2) The first assembly being completed the top strake C was taken to the ground and a further two strakes D and E built on top.
(3) This procedure was continued until all outer shell strakes with their corresponding circumferential beams had been related one to the other.

Hemispherical Ends on Outer Shell

The outer shell was closed at either end by hemispherical ends; these formed part of the strength shell and were known as the high speed end and slow speed end, the terms being self-explanatory. Both domes were reinforced with twelve built-up beams, which radiated from a central fulcrum to join up, at the first strake of shell plating, with the longitudinal beams extending the entire length of the tunnel. The fulcrums in both cases were castings, bought in rough and machined in our engineering shops.

Within the hemispherical ends the air-stream was rotated through 180 deg. by means of high speed fairings and slow speed fairings, as illustrated in Figs. 1, 14 and 15. These fairings were formed of $\frac{1}{4}$-in. thick plating, shaped figuratively like an inverted umbrella with reinforcing ribs. The $\frac{1}{4}$-in. thick domed plates were pressed cold and the $\frac{1}{4}$-in. fairing plates hot, special male and female blocks being fabricated for this work. Special jigs were also built for milling these plates on edge; generally these were of a concave ribbed structure, into which the plates were clamped and the whole assembly inclined to the required angle, to suit the vertical milling cutter.

This procedure proved successful except in the case of the twelve plates marked "X" in Fig. 15. On the slow speed end no cooling jacketing was required on the outer plating, since the air-stream did not come in contact with this plating, but was diverted prior to this point; on the high speed end, however, the air-stream was not returned until part way along the dome and consequently the latter required a cooling circuit. Jacketing, similar to that on the outer shell, was adopted and the welding and edge milling jigs were combined to save time and material. This was a convex ribbed structure curved in both directions, on top of which the plates were clamped, followed by the channel sections and joggled plates. As in the case of the outer shell plates, to allow for weld contraction the radii of the ribs were quickened. When all production welding on these plates was completed, the entire assembly was taken to the vertical mill, the jig inclined until the required bevel on the plate edge was obtained and the milling operation completed.

For the production of the hemispherical ribs, high speed and slow speed ends, the welding jig used for the fabrication of the outer circumferential beams was utilised, the same precautions being taken against weld contraction and distortion and similar weld procedures adopted.

At the slow speed hemispherical end, an interesting detail occurred at the junction of the last strake of shell plating, the first of the dome plating and the commencement of the fairing plating (Fig. 16). It was essential for the fairing plating to be flush with the shell plating, since any proud edges at this point might set up oscillations in the air-stream which would be detrimental to experimental readings on models suspended in the working section.

Consequently, to ensure a perfectly fair joint, round washers were tack welded on the back of the fairing plates at each bolt hole (this also provided a reinforcing pad at these holes, since the plating was actually too thin for countersinking purposes to suit cheese-headed bolts), each of the latter plates was fitted individually in position and, if showing any proudness, the washers were ground down until a perfectly flush joint was obtained. This was a long and tedious task, but appeared to us at the time as the only solution to the problem and one which was finally successful.

The fitting of the two hemispherical ends to their adjacent shell plates was carried out as shown in Figs. 14 and 15. The domes were erected in our workshops in a cup-like fashion, their respective end castings being seated on the shop floor, temporary erection brackets welded to the twelve hemispherical ribs and timber shores taken from these to the shop floor for stabilising purposes. When all dome plating had been erected, the fairing plating, with its accompanying ribs, etc., was erected within and shell strakes A and L fitted on top, complete with the first and last of the circumferential rings.

From the foregoing, it will be readily appreciated that every precaution was taken to ensure that all the outer shell plating, circumferential beams and hemispherical ends would fit at site, with the minimum of work and as expeditiously as possible.

Inner Shell

The general construction of the inner shell was on similar lines to that of the outer shell, but nevertheless various little problems arose.

It was not a strength shell nor to be regarded as airtight, but had to be reasonably so; a cooling circuit was necessary, since one face of the shell was in contact with the airstream, and in this case the jacketing system and circumferential beams were on the concave side of the plates. Difficulties were also experienced because the shell, although circular in cross section, tapered in longitudinal section from 34 ft. 7 in. dia. at the high speed end, to 28 ft. dia. at the slow speed end (Fig. 17). The width of strakes was similar to those in the outer shell, generally 8 ft. 10 in. in circumference, each composed of six plates, the circumferential beams being on similar lines and the joints of the latter staggered with those of the shell plates.

The jacketing system in the inner shell was again composed of 12 in. × 4 in. channels and plates and the latter were set to radius in the horizontal press by methods similar to those adopted for the outer shell sections, the shape of the male and female blocks being reversed. By referring to Fig. 18, it will be seen that merely to curve the channels and place them toe on to the plating was

nut the answer, as because of the conical nature of the plate, a corkscrew effect would result. To overcome this, prior to being set, one toe of each channel was planed to such a depth that, when seated on the plate, the web of the channel was parallel with the longitudinal axis of the tunnel. The intermediate plating was positioned as shown on Fig. 18, and this provided good fillet welds.

The assembly and welding jigs were as shown in Fig. 19, being again formed of ½-in. web plates, seated on a joist grillage and tied by light channel sections, but in this instance the entire assembly was a concave structure. In order to retain the conical shape of the inner shell, each rib differed in radius and once again allowances were made for weld contraction and distortion. These allowances are shown on Fig. 19; in this instance the initial set of the plate was made more "open" than its final shape (as compared with an initial "closing" of the outer shell) and was "broken" in cross section as shown in sketch.

Clamping and jacking arrangements, similar to those used on the outer shell jigs, were adopted and as previously the entire assembly was seated on trunnion bearings which permitted rotation, resulting in downhand welding at all times, a feature much appreciated by welders and inspectors.

Inner Circumferential Beams

The fabrication of the inner circumferential beams provided more problems, due to their circular shape and the fact that, since one flange provided the cover for joining the inner shells in circumference, it required to be inclined to the web, the other flange remaining square. Our clients' design was for a 12 in. × 6 in. joist section; our answer was two tee sections 6 in. × 6 in. × ¾ in. welded toe to toe to give the required joist section, since the curving of a joist section at any time is a difficult piece of smithwork, the web having a tendency to buckle or collapse and with one flange requiring to be splayed, our difficulties would have been greatly increased. The adoption of tee sections made the problem a comparatively easy one and the tees were fabricated as shown in Fig. 20. Curved male and female blocks were machined as shown, one set having a slight bevel to suit the slope of the inner shell; tees for the largest diameter beams were set first, and the blocks remachined for each set of circumferential beams, the radius being decreased each time.

Minor modifications were made to the assembly and welding jig for the outer circumferential beams (Fig. 12) and into this the tee sections were fitted; clamping arrangements and welding procedures, distortion and weld contraction allowances similar to those used for the outer beams were applied, and, in general, we had by this time a reasonable grip of the job. For the welding of the tees toe to toe the sections were prepared at this point prior to being set to radius, the preparation being a vee on both sides (machined in horizontal plane). A joint of this nature would now probably be carried out by deep penetration welds from either side, but our welding research at that time had not reached this stage.

As in the case of the outer circumferential beams, the inner sets were built under the rotary plane and machined to a true diameter for the full depth of the splayed flange, all joints being drilled in position for fitted bolts, marked for their respective positions and thereafter returned to the erecting shop for further fitting. The outer shell procedure for proving each strake of plating to its adjacent strake and circumferential ring, was applied to the inner shell (Fig. 13) and by this means the entire shell was shop fitted.

It was essential that the inner shell should be shop assembled, because of its having a hollow core known as the *contraction cone*, *working section*, *expansion cone* and *fan ring*, these sections being supported generally by ties and struts from the inner circumferential beams. This erection was accomplished by cradling at the invert strake on the shop floor and shoring by rakers from the floor to the half-way level, temporary brackets being fitted at this point.

Contraction Cone, Working Section, Expansion Cone and Fan Ring

The diagrammatic shape of these various sections can be seen in Fig. 17. As in the case of the sections of the structure previously detailed, these parts provided their difficulties, but only in the case of the *expansion cone* was welding extensively used.

The air-stream was diverted around two sets of castings, one at either end of the inner shell, known as the *slow speed bull-nosed castings* and *high speed bull-nosed castings*. These consisted of twelve sections to each ring, purely circular, brought in roughcast to our engineering shops, machined to a smooth finish under the rotary plane, and thereafter fitted to the shop assembly of the inner shell.

In the case of the contraction cone, the difficulties were mainly structural ones, since it was generally a bell-mouthed structure composed of ¾ in. thick plating reinforced by 10 in. × ¾ in. flats tack welded on edge. On cross section the cone was divided into quadrants and despatched to site in this manner, being held in position at site by four swan-neck shaped beams about 25 ft. long. For fabrication purposes the latter were again composed of tees welded toe to toe, as in the case of the inner circumferential beams. No cooling circuit was required in this area, since the air-stream velocity at this point had dropped considerably.

From the *contraction cone* the air-stream passed to the *working section*, this being the area in which model planes, plane sections, etc., were suspended for testing purposes. This section was rectangular, about 10 ft. × 7 feet × 15 ft. long, built up entirely of cast sections machined in our engineering shops and retained in position by fitted barrel bolts. Observation windows were provided at the sides and top and removable sections on the base, through which struts passed down from supporting the models to the balance car, the latter being the agent which recorded the reactions of the object under experiment. There was no welding in this area.

The *working section* was followed by the *expansion cone*, the name being self-explanatory. This was an extremely difficult section to fabricate, its cross-sectional shape varying from rectangular at the *working section* end to a pure circle adjacent to the *fan section* over a distance of approximately 50 ft. In addition, a cooling circuit was necessary, since the air-stream velocity was very high because of its proximity to the fan, the latter being the agent responsible for the circulation of the air within the structure.

In the case of the *expansion cone*, it was found necessary to build assembly, welding and milling jigs for almost every strake of plating. Fortunately, it was found practicable to combine the three types of jigs so that one served all purposes. Fig. 21 gives some indication of the nature of the jacketing on the cooling system. As in the case of the inner shell, the web of the sections was kept parallel to the axis of the tunnel so that any corkscrew effect was avoided. Channel sections were again used. In some instances only the toe of one flange required planing to comply with the above conditions, but in cases where the "opening-out" of the cone was extremely severe, it was found necessary to remove one flange entirely and build the system as shown in Fig. 21. This construction provided excellent positions for fillet welding and the entire jig being housed on trunnion bearings for rotation, good positional welding was obtained. Allowances were again made for weld contraction and distortion, and although of an awkward shape, we succeeded in turning out the sections to the satisfaction of our clients' inspector.

The *fan section* provided very little difficulty in fabrication. It was constructed of 2-in. thick plating 3 ft. 1½ in. wide and 16 ft. dia., six sections forming the circle. Reinforcement was provided by 1-in. thick plates on either edge. The assembly was fully welded before being machined to a true diameter. This section was specially supported by joist sections from the circumferential beams on the inner shell and an elaborate jacking system was fitted to the ends of these supports, so that, at site, the entire section might be carefully aligned to the fan itself. The tolerance between the machined face of the section and the fan blade tips when the latter were stationary was 0·3 in., but naturally this clearance was greatly decreased when the fan was running at full speed, so that our setting at site of this section was extremely critical. As a safeguard, "cut-out" needles were set at six points in the circumference of this section, these projecting about 0·1 in. proud of the machined surface, so that, if contacted, they automatically stopped the fan motor.

The above is a general resumé of the sections which formed the annular passage within the inner shell.

INTERESTING FEATURES AND DETAILS

(a) Honeycomb

A structure, known as the honeycomb, was fitted between the bull-nosed casting in the slow speed end. This was approximately 24 ft. in diameter and composed of thousands of hexagonal aluminium tubes, 1 in. across flats and 6 in. long. These tubes were spot-welded together in jigs and sent to site in sections, as

shown on Fig. 22. The purpose of this structure was to "settle" the air-stream after being rotated through 180 deg. and prior to entering the working section. This decreased the possibility of oscillations in the air-stream which would have had an effect on the recordings taken on models within the working section.

(b) Cheese-headed Barrel Bolts

The majority of the site joining in the tunnel structure was made by the use of cheese-headed barrel bolts (Fig. 23). A good deal of experimental work was carried out in our workshops prior to this type of bolt being adopted and our research was based on outer shell pressures. The bolt had a two-fold purpose; it must be of a barrel or fitted type to prevent movement at the joints; it must be able to provide an air-tight seal to withstand an internal pressure of 45-50 lb./sq.in. The bolt, as shown on sketch, proved satisfactory, the barrel section providing rigidity at the joint and the lead washer the seal. Extreme care was exercised at site to ensure that the cheese head of the bolt was not proud of the plating, and in the workshops during drilling, that the countersink was concentric with the holing in the plating.

(c) Supports for Balance Car Rails

It was essential that the rails, supporting the balance car within the tunnel, should be level to within 1/20th deg., and at the same time be immune from any tunnel vibration. The two rails were formed of mild steel billets, 3 in. thick and 1 ft. 10 in. deep, each supported by four solid mild steel pillars 10 in. dia. The arrangement can be seen diagrammatically on Fig. 24. The rail adjustment was obtained by providing jacking screws and finely tapered wedges at the top of the pillars, a deep slot being made in the latter to accommodate the rail. The bases of the pillars were seated in solidly welded stools set on a concrete foundation, the latter being entirely independent of any other foundations. The 10-in. dia. pillars passed through 12-in. dia. holes in the outer and inner shells, the air-tight seal being formed by means of a specially moulded rubber seal attached to the pillars and shells. The pillars passed between the outer and inner shells and consequently provided an obstruction in the air-stream; to overcome this two thinly plated aerofoils were erected around the four pillars, the shape being streamlined.

(d) Outer Access Door

Access to the working section of the wind tunnel was obtained by doors on the outer shell, inner shell and the first section of the expansion cone. As the two latter portions were not strength shells, the doors were of a lightly hinged type and locked with a few tapped bolts. The outer door, however, being part of the outer shell, required further consideration. These doors were approximately at the halfway level, there being a control room in the building proper at this level. The outer door travelled on a trolley in the control room and was hand operated by worm wheels and gearing, and for strength purposes it was reinforced by 1 in. thick ribs vertically and horizontally, the entire structure being welded with ¼ in. fillet welds. For air-tightness, a rubber seal was set into a grooved block which surrounded the door, there being a similar machined but ungrooved block on the tunnel proper, against which the rubber seal was pressed by 1¼ in. dia. bolts with brass nuts studded along the edge of the door. The door, on being closed and drawn up to the tunnel, was then loosely released from its travelling carriage, since the tunnel structure expanded under internal pressure.

(e) Metal Spraying of Windswept Surfaces

It was essential for all surfaces in contact with the air-stream to be as smooth as possible, and our clients requested a zinc finish on these faces. To comply with this specification, it was necessary to instal special plant within our workshops, since so many sections had to be treated in this manner (outer and inner shells, contraction and expansion cones, working section, etc.). Two completely enclosed cubicles were built, one for sand-blasting prior to spraying, and one for zinc spraying—three coats, each 0·002 in. thick, the materials travelling in and out of the cubicles on trolleys.

The zinc coating, on being brushed, gave a highly glossed finish, and consequently at site, to decrease frictional resistance, the working section, contraction cone and expansion cone were treated in this manner. To expedite this work, brass bristle brushes, of varying shapes and sizes, were supplied to us by a well-known brush manufacturing firm, these being specially manufactured to suit our standard type of pneumatic air grinding machines, the grindstone in this case being removed and replaced by brushes. The finish was very good.

(f) Lining of Fan Shaft and Bearings

The lining of the fan shaft and bearings at site proved interesting. The shaft was approximately 32 ft. long, being supported on three bearings within the tunnel and two bearings at the fan motors, the latter being located in the generating house. In order to accommodate any movement between the tunnel structure and the fixed building, the shaft was divided in two, a Bibby coupling being fitted at the joint. A curious feature arose during the shaft alignment. In order to accommodate our erection, the tunnel building was not completed, the erection of one side and the roof being delayed. The alignment was due to be carried out about mid-summer and the mid-day temperature in Farnborough at this time can be quite high, as it happened to be that year.

In the course of our aligning, which was carried out during normal working hours, we found our readings varying from hour to hour. An investigation on the underside of the structure, with the use of extensometers, showed that, during the heat of the day and with the method of support (all temporary supports having been removed) and the building conditions prevailing at that time, the structure was drooping at the hemispherical ends and rising between the supports. This was the result of expansion due to heat on the top of the structure, the underside remaining stationary because shaded (Fig. 25). The difficulty was overcome by carrying out our aligning and levelling during the very early hours of the morning. This feature, naturally, did not appear when the building structure was completed, since the latter was insulated with 7 in. of cork, etc., on floor, walls and roof.

(g) Tunnel Expansion

When finally erected, the tunnel structure was supported on four feet which in turn rested on concrete plinths. It was anticipated that the structure would expand under internal pressure and consequently the bearings must be designed to accommodate this, the stationary or "fixed" end being at the fan shaft. The layout of the sliding bearings was as shown on Fig. 26; a 1½ in. thick bearing foot sliding on 3 in. × ¼ in. thick machined phosphor bronze strips fixed on a 1½ in. thick mild steel bedplate, the entire assembly being immersed in an oil bath.

ERECTION AT SITE

Thanks to careful shop procedure the site erection of the structure proceeded steadily with few difficulties. Careful aligning and levelling, however, had to be carried out until such time as the structure was a complete unit, since its final means of support was by two heavy circular box-type beams resting on four feet on concrete plinths.

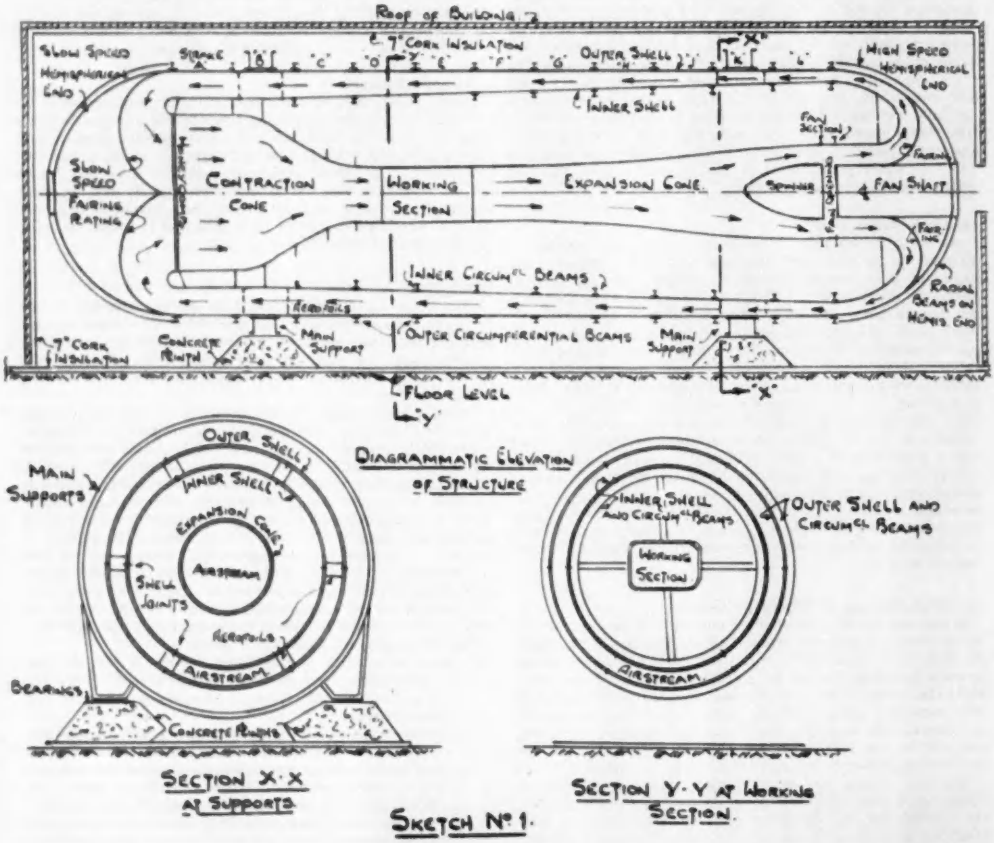
While the workshop fabrication on the various sections was proceeding, the writer had always borne in mind the difficulties which might arise at site and had worked out a site erection scheme many months before the first materials left Glasgow. Brackets were shop welded to the outer circumferential beams as depicted on Fig. 27, being of sufficient area to accommodate 12 in. × 12 in. timber shores, the latter resting on timber folding wedges. By adjusting the outer or inner shores, the vertical or horizontal diameters are correspondingly effected, and by this means at site the correct diameter of each set of circular beams was obtained. Two sets of timber shores were also set underneath the castings on the hemispherical ends and by this means the correct relationship of the domes to the outer shell was achieved.

The site erection sequence was as follows:—

1. Erect invert plate of outer shell for full length of shell, supported by two outer circumferential beams. Align and level carefully with relation to foundations already set and fan machinery.
2. Continue erection of shell plating up to halfway level and complete erection of all circumferential beams. By this means the cellular shape was quickly formed and was subsequently maintained, the circular beams being only broken when the occasion demanded, and only one at a time, the section being replaced at the earliest opportunity.
3. Erect hemispherical ends, high speed and slow speed, complete with fairing plates and align to portion already erected.

4. Commence erection of inner shell plating for full length, up to halfway level and inner circumferential beams completely, thus forming the inner cellular shape. As in the case of the outer shell, the inner structure was temporarily supported from the outer for its entire length, folding timber wedges being used at the invert shell and special jacking screws at the halfway level. By this means the inner structure was easily aligned and levelled with relation to the outer shell; this alignment was required to be concentric.
5. Erect inner core, comprising contraction cone, working section, expansion cone, fan ring, and bull-nosed castings at either end.
6. Close inner shell plating, and finally close outer shell plating. Very little difficulty was encountered during the last operation, since a continuous check had been maintained on the square of the circumferential beams with relation to the longitudinal axis of the structure—at each strake joint by means of theodolite.
7. The erection of the honeycomb and fan blades, and the lining of the fan shafting were carried out when all the above erection had been completed, the various sections being man-handled through the access door in the side of the tunnel.

The above is a very general resumé of the site erection programme. The entire structure was erected on its temporary supports ½ in. higher than its final level and our anticipated settlement after all shores were removed was resonable, this being about ½ in. The essential criterion at all times was to maintain the cellular shape of the various shells and to keep within the tolerance limits.



Sketch No 1.

Fig. 1. General outline of wind tunnel.

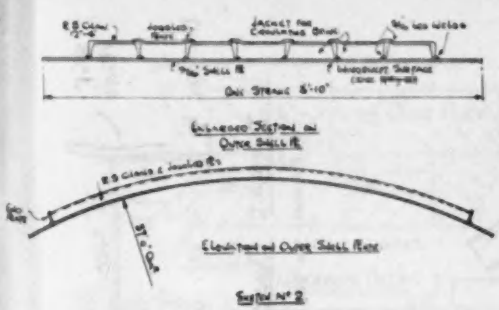
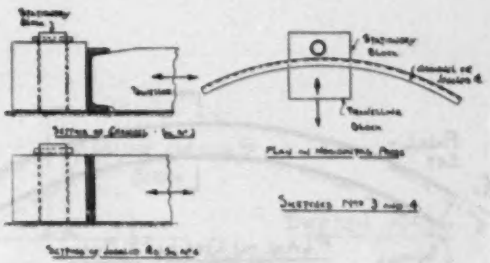


Fig. 2. Assembly of cooling circuit on outer shell.



Figs. 3 & 4. Detail of press blocks for setting outer channels and for joggled plates.

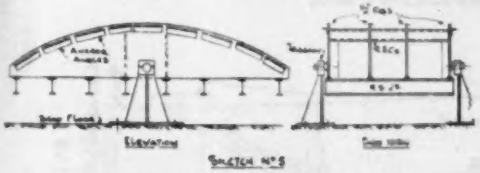


Fig. 5. Assembly and welding jig for outer shell

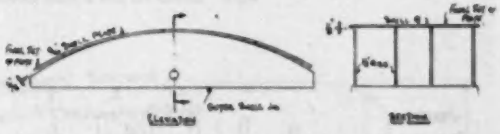


Fig. 6. Diagrammatic view of outer shell on jig

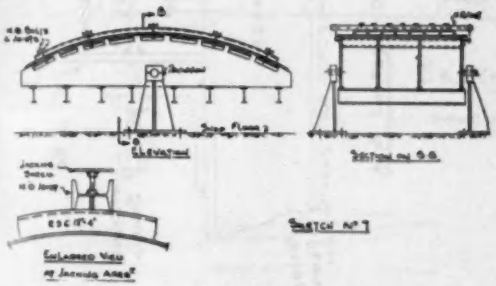


Fig. 7. Complete assembly of outer shell on welding jig

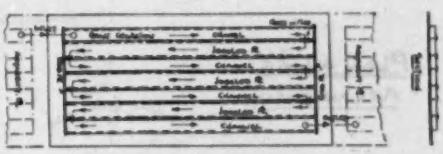


Fig. 8. Diagrammatic view of brine circulation on one outer shell plate

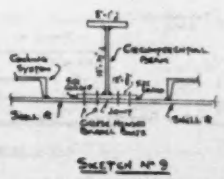


Fig. 9. Enlarged section through outer circumferential beam

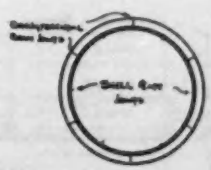


Fig. 10. Arrangement of outer shell plates to circumferential beam

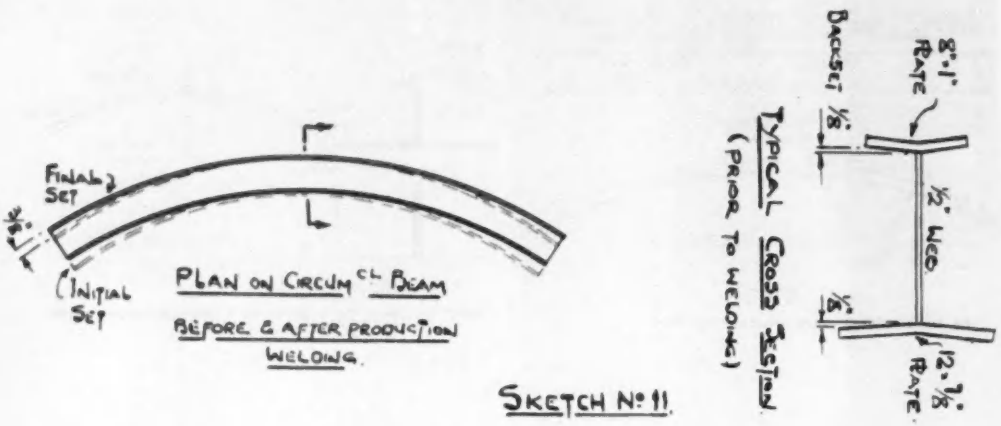


Fig. 11. Section and plan of outer circumferential beam prior to welding

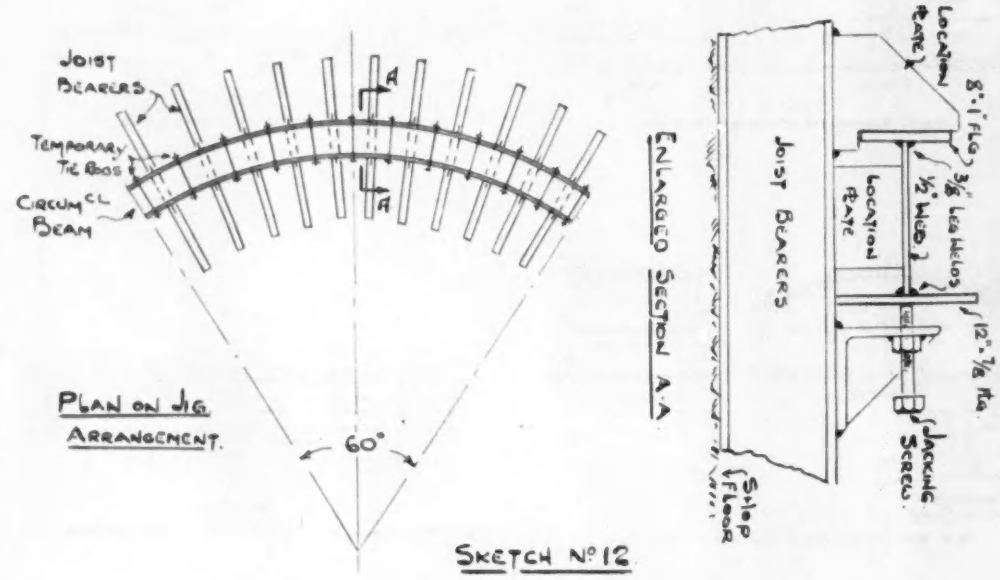


Fig. 12. Assembly and welding jig for outer circumferential beams

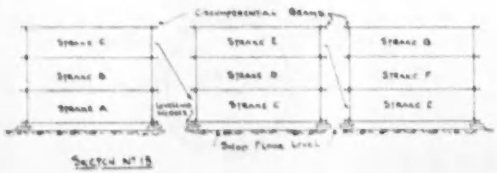
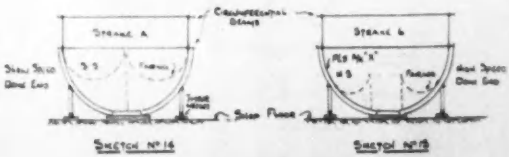


Fig. 13. Arrangement for shop assembly of outer shell



Figs. 14 & 15. Arrangement and shop assembly of slow speed and high speed hemispherical ends.

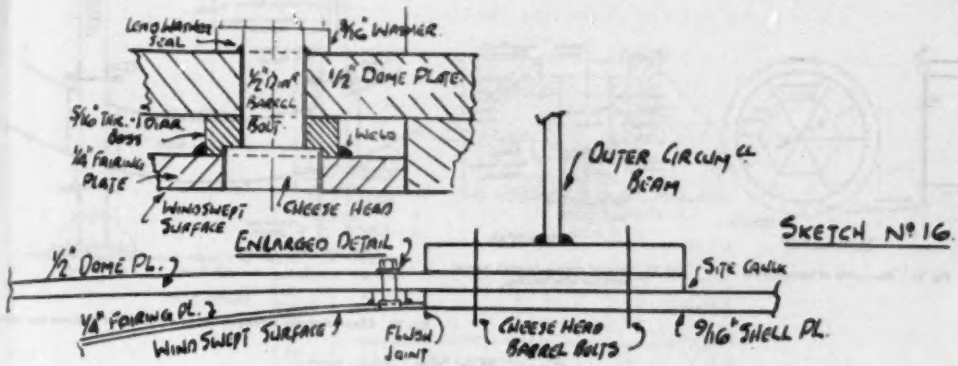
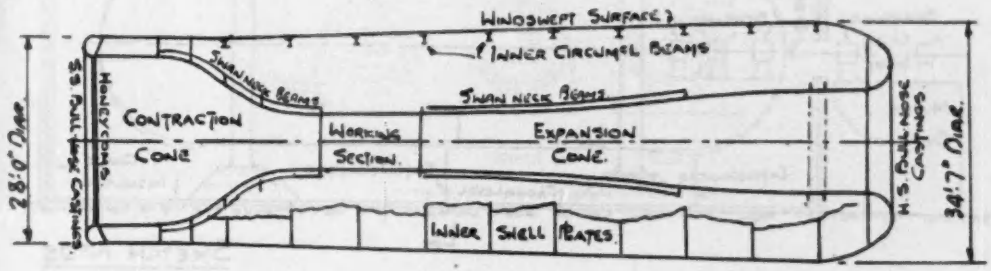


Fig. 16. Enlarged arrangement of fairing to outer shell



SKETCH No 17

Fig. 17. General arrangement of inner shell

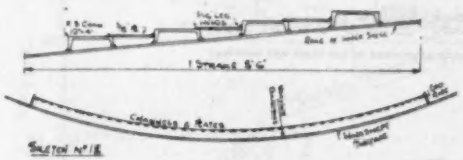


Fig. 18. Assembly of cooling circuit of inner shell

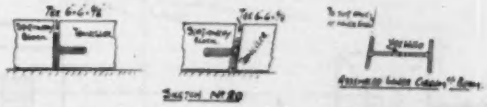


Fig. 20. Press blocks for setting inner circumferential beams

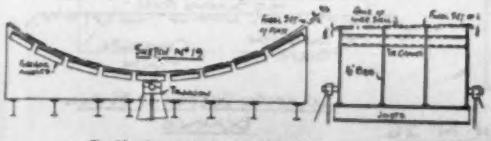


Fig. 19. Assembly and welding jig for inner shell

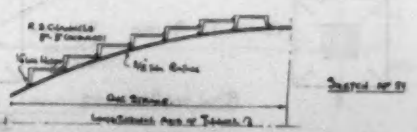


Fig. 21. Typical assembly of cooling circuit on expansion cone

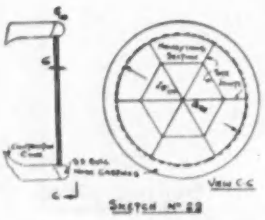


Fig. 22. Assembly of honeycomb

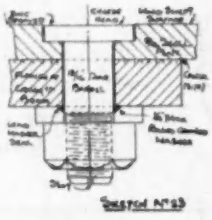


Fig. 23. Typical cheese-headed barrel bolt for site bolting

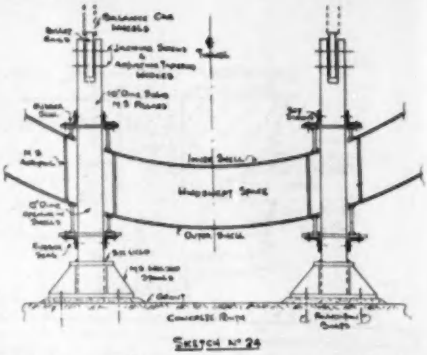
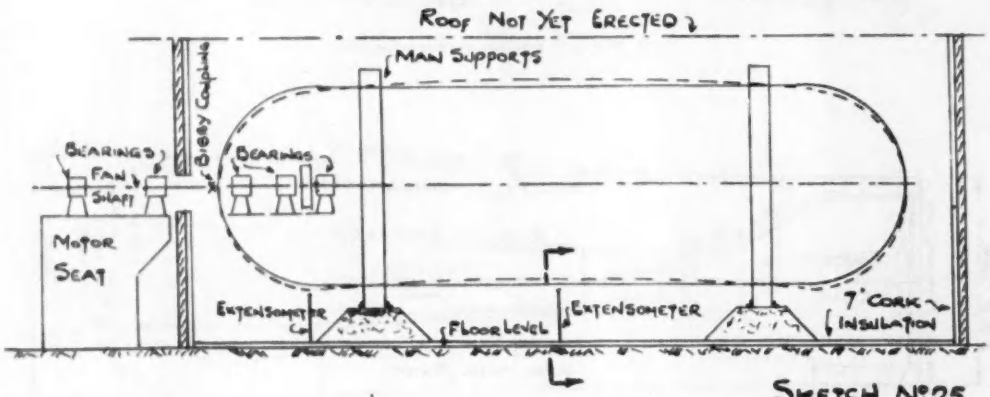


Fig. 24. Diagrammatic arrangement of supports for balance car rails



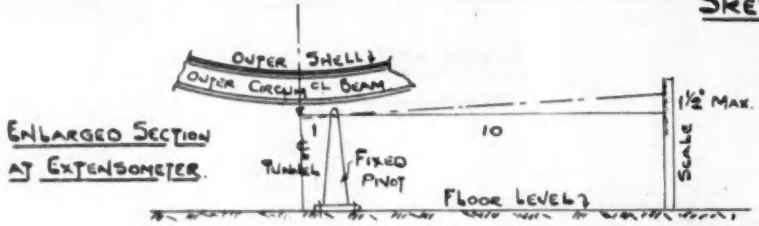


Fig. 25. Diagrammatic view of tunnel distortion during alignment of fan shaft and bearings

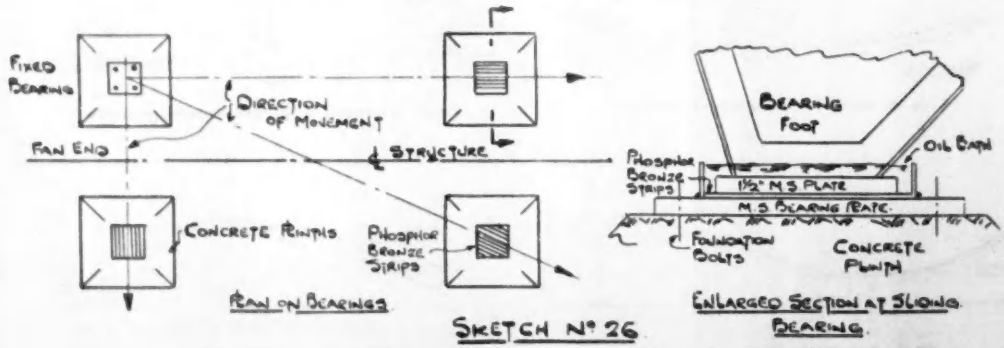


Fig. 26. Bearing stools for tunnel expansion

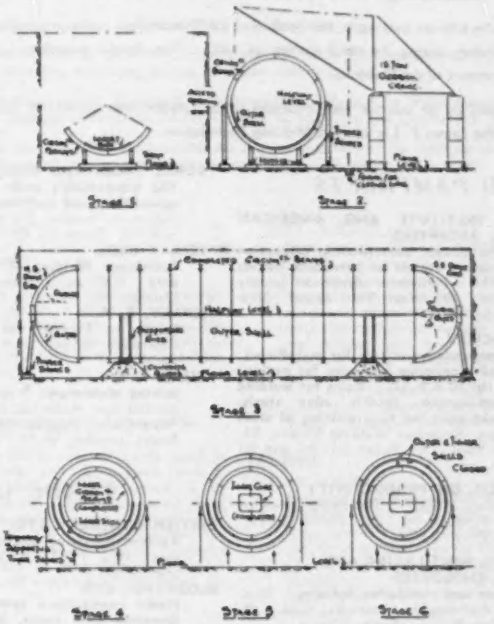


Fig. 27. Site erection diagrams

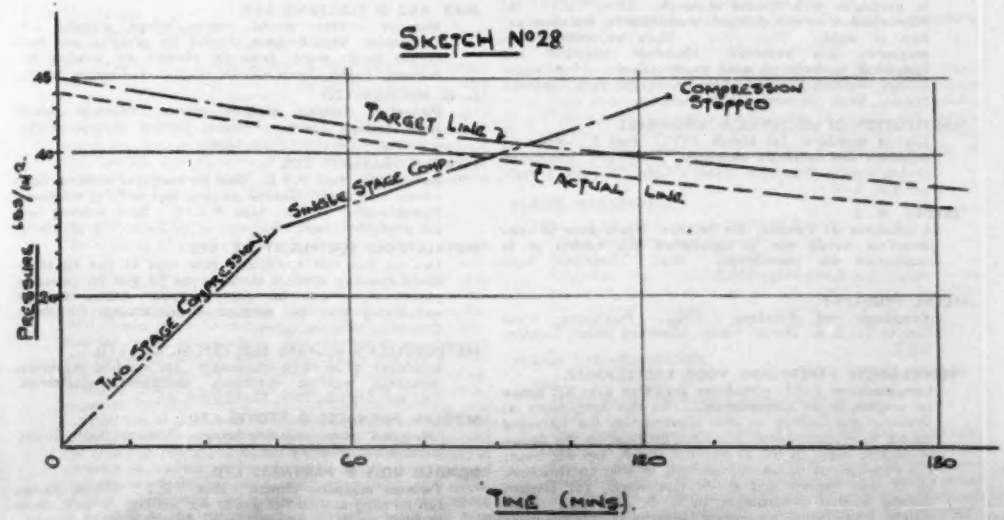


Fig. 28. Graph of pressure tests on tunnel

Latest Additions to the Library

As a supplement to the Library catalogue, this section of the *Transactions* contains particulars of books and pamphlets added to the Library during the third quarter of 1952. The books, pamphlets and periodicals specified are available on loan to members of the Institute.

Publications preceded by an asterisk are donations to the Library from authors or publishers; those preceded by a dagger are donated by the James F. Lincoln Arc Welding Foundation.

BOOKS AND PAMPHLETS

AMERICAN PETROLEUM INSTITUTE AND AMERICAN SOCIETY OF MECHANICAL ENGINEERS
API-ASME Code for the design, construction, inspection and repair of unfired pressure vessels for petroleum liquids and gases. 5th ed. 1951. Publishers: American Society of Mechanical Engineers, 29, West 39th Street, New York, 18. Price: 3 dollars.

***AMERICAN WELDING SOCIETY**
(a) (C.2.2-52T). Recommended practices for metallizing: Part 1B.—Application of aluminium and zinc for protection of iron and steel. (b) (D.3.4-52). Rules for welding piping in marine construction, ferritic alloy steels. (c) (D.5.1-52). Standard rules for field welding of steel storage tanks. Publishers: American Welding Society, 33, West 39th Street, New York, 18. Price: (a), (b) and (c) 50 cents each.

ANGLO-AMERICAN COUNCIL ON PRODUCTIVITY
Steel construction. Illus. 1952. Publishers: Anglo-American Council on Productivity, 21, Tothill Street, Street, London, S.W.1. Price: 3/-.

***ASSOCIATION OF HEATING, VENTILATING AND DOMESTIC ENGINEERING EMPLOYERS**
Year book of the heating and ventilating industry. Illus. 1952. Publishers: Technitrade Journals Ltd., 8, Southampton Row, London, W.C.1. Price: 7/6.

***BRITISH CONSTRUCTIONAL STEELWORK ASSOCIATION**
The collapse method of design, being the application of the plastic theory to the design of mild steel beams and rigid frames. Illus. (B.C.S.A. Pub. No. 5-1952). Publishers: British Constructional Steelwork Association, York Mansion, 94/98, Petty France, London, S.W.1.

***BRITISH WELDING RESEARCH ASSOCIATION**
(a) T.27.—The industrial use of flash welding, dealing in particular with ferrous materials. Illus. 1951. **(b) Memorandum on non-destructive methods for the examination of welds.** Illus. 1952. **(Data on radiographic, magnetic, d/e penetrant, electrical, chemical and acoustical methods of weld examination).** Publishers: British Welding Research Association, 29, Park Crescent, London, W.1. Price: (a) 2/6; (b) 5/-.

***INSTITUTION OF MECHANICAL ENGINEERS**
List of members, 1st March 1951. Part 1.—Honorary members and corporate members. Publishers: Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1.

***JAEGER, H. E.**
L'influence de l'emploi des metaux, legers dans la construction navale sur la conception des navires et la realisation des assemblages. Illus. (Reprinted from Aluminium Suisse, May 1952).

METAL INDUSTRY
Handbook and directory. 1952. Publishers: Louis Cassier Co. Ltd., Dorset House, Stamford Street, London, S.E.1.

***NEDERLANDSE VERENIGING VOOR LASTECHNIEK**
Lassymposium 1951.—Moderne inzichten over het lassen en snijden in de scheepsbouw. (To this Symposium on Welding and Cutting in Ship Construction the following papers were contributed: (1) Consideration on the design of welded ships, by W. P. Kerkhof and A. van der Neut; (2) Applications of welded sections in ship construction, by D. van Nievelt and A. A. Gasterland; (3) Oxygen cutting in ship construction, by B. B. Zinkweg.) Publishers: Nederlandse Vereniging Lastechniek, Stadhouderslaan 102, 's-Gravenhage.

***RURAL INDUSTRIES BUREAU**
The blacksmith's craft: an introduction to smithing for apprentices and craftsmen. Illus. 1952. Publishers: Rural Industries Bureau, 35, Camp Road, Wimbledon, London, S.W.19. Price: 8s. 6d.

***SCIAKY BROS.**
Resistance Welding at Work, Vol. 1, No. 3, 1950, to date. Publishers: Sciaky Bros., 4915, West 67th Street, Chicago 38.

***SCIAKY, S. A.**
Sciaky au Travail, Vol. 1, Bulletin 2, 1951, to date. Publishers: Sciaky S. A., 13 et 15 rue Charles Fourier, Paris, 13.

***WEST, E. G.**
Joining aluminium: A summary of present practice. (Reprinted from *Adhesion*, June, 1952). (RP36). Publishers: Aluminium Development Association, 33, Grosvenor Street, London, W.1.

TRADE CATALOGUES

BRITISH RONCERAY LTD.
Reclaim defective castings with the new Dot Weld process. Illus. 1952. Address: Benefit Buildings, Moorhead, Sheffield, 1.

ELCONTROL LTD.
Flame conductivity system FSC for gas burners. The Elcontrol weld timer, WT 2. Address: 10, Wyndham Place, London, W.1.

ILFORD LTD.
X-ray materials. X-ray accessories. Address: Ilford, London.

LAURENCE, SCOTT & ELECTROMOTORS LTD.
The Scott "C-S" type direct current welder. It's simple with a C-S welder. Petbow engine-driven plant incorporating C-S generators. Address: Manfield House, Southampton Street, London, W.C.2.

MAX ARC & ELECTRICS LTD.
Max-arc welder; petrol engine driven welding set; accessories; Max-Arclectric electric arc welding set; twin carbon torch; motor generator electric arc welding set. Address: 44-46, Terrace Road, Walton-on-Thames, Surrey.

C. G. MEGSON LTD.
Protective clothing; welders' gloves, industrial gloves, spats, sleeves, apron. Address: Central Leather Works, Connaught Street, Oldham, Lancs.

MERITUS (BARNET) LTD.
Butt welder, type H.B.3. Dual purpose spot welding: light alloys, mild steel. General purpose spot welding machines. Portable plier welder, type H.S.10. Spot welding will cut production costs. Address: Wood Street, Barnet, Herts.

METALLIZING EQUIPMENT CO. LTD.
Low air, low cost metallizing gun; type 4E gun for high-speed spraying with all metals; type 5E gun for corrosion protection; a gun for every purpose; Metco type Y metallizing gun for production metallizing. Address: Chobham, Woking, Surrey.

METROPOLITAN-VICKERS ELECTRICAL CO. LTD.
Catalogue of welding equipment: arc welding machines, resistance welding machines, electrodes, accessories. Address: Trafford Park, Manchester, 17.

MODERN FURNACES & STOVES LTD.
"Newstad" stress relieving furnace. Address: Booth Street, Handsworth, Birmingham, 21.

DONALD ROSS & PARTNERS LTD.
Twinner magnetic clamps. Illus. 1952. (These clamps can be used with either gas or arc welding on butt, seam or fillet welds.) Address: 1-3, Arlington Road, London, N.W.1.

Abstracts from Recent Welding Literature

(Compiled by J. L. SANDERS)

THIS section of *Transactions* makes no pretension to completeness but is intended only to provide readers with particulars of some of the more interesting papers appearing in recent welding periodicals.

Readers who need a complete survey should consult the *Bibliographical Bulletin for Welding and Allied Processes* published quarterly by the International Institute of Welding. Particulars may be had from the Secretary of the Institute.

Publications mentioned in the lists below are available on loan to members of the Institute and borrowers will facilitate matters if they will quote the appropriate reference number printed beside each entry.

ARC WELDING.—Electrodes

1672. ANON.
Storage of arc welding electrodes
Welding & Metal Fab., vol. 20, 1952, Sept., p. 325

There are two methods of keeping electrode coatings dry. One method is to provide a store in which the temperature is always 10° C. above that of the outside air and the other is to remove moisture from the air by means of a hygroscopic substance. Both these methods are explained in this brief article.

1673. FABRYKOWSKI, Z. J.
Ferritic welding electrodes save alloy: give better welds
Iron Age, vol. 170, 1952, July 24, pp. 93-97

Low hydrogen ferritic type electrodes are being used in the fabrication of armour plate up to ½ in. thick for U.S. military vehicles and it is claimed that a saving of 85 per cent. in alloy consumption is obtained by using these electrodes instead of the austenitic type. Physical properties of the joint are good. The author outlines the development of this type of electrode making reference to U.S. government specifications and details of impact properties, heat treatment and cracking susceptibility are given.

ARC WELDING.—In Inert Atmospheres

1674. ANON.
The arganarc welding process
Light Metals, vol. 15, 1952, July, pp. 232-234

The reasons why it is essential to use an alternating current when welding aluminium and its alloys by the argonarc process are explained and the article is very clearly illustrated by diagrams of the arc under different current conditions.

1675. ANON.
Alloy-metal welding
Metal Ind., vol. 81, 1952, Aug. 22, p. 153

A brief article on a new American attachment for manual inert-gas-shielded arc welding equipment which renders it semi-automatic in operation. The device consists of a special water-cooled torch, which is provided with means for pulling a filler wire from a spool to the arc, and a mechanical power unit. The feed rate is variable and may be stopped without interrupting the arc. It is stated that the advantages of this attachment are greatest on materials less than 3/16 in. thick.

1676. CHYLE, J. J.
The welding of copper by the inert-gas metal-arc process
We.ding J., vol. 31, 1952, Aug., pp. 663-636

This article contains a brief account of the historical uses of copper and its refinement from its ores. The various processes for copper welding are outlined and the author then passes on to a detailed account of the inert-gas-shielded metal arc process. The relative merits of pure and thoriated tungsten electrodes, helium and argon, A.C. and D.C. supplies are considered and welding procedure, including the influence of type of joint preparation, sequence of layer deposition, position of welding and composition of plate and filler material, is described. The technique of this process is covered in some detail and the effect of peening is noted. The mechanical properties of joints in various grades of copper are investigated and the results of tensile, bend and impact tests and radiographic examination are presented. Considerable space is devoted to the microstructure of weld metal and base material and examples of typical fabrications are shown.

1677. ROCKFELLER, H. E.
Inert-gas-shielded arc consumable electrode welding
We.ding J., vol. 31, 1952, July, pp. 575-586

The principle of the shielded-inert-gas metallic arc or "sigma" process is described and examples of hand and automatic equipment are given. By the addition of a small percentage of oxygen to the highly purified argon, the droplet rate may be increased by fifty times and hence a higher welding speed may be obtained. The application of the process to the fabrication of aluminium tank cars, aluminium deck sections for pontoon bridges, aluminium trusses for portable hangars, laminated copper busbars, stainless and carbon steel components is covered.

BRAZING

1678. ANON.
Proposed tentative specifications for brazing filler metals
We.ding J., vol. 31, 1952, Aug., pp. 645-650

This article sets out the proposed A.W.S.-A.S.T.M. specifications for brazing filler metals of the aluminium-silicon, copper-phosphorous, silver, copper-gold, copper, copper-zinc, magnesium and heat resisting types. This specification covers classification by chemical composition, standard forms, sizes and tolerances, packaging and marking. Mechanical properties are not considered. The operating characteristics and applications of each class are given.

1679. BURT, F. M.
Modern methods for copper brazing
We.ding Eng., vol. 37, 1952, July, pp. 30-34

A general article on copper brazing in the controlled atmosphere furnace.

1680. PEASLEE, R. L. and BOAM, W. M.
Design properties of brazed joints for high-temperature applications.
We.ding J., vol. 31, 1952, Aug., pp. 651-662

Stainless steels can be satisfactorily brazed for high temperature service by employing a nickel-chrominium base filler alloy and brazing in a reducing atmosphere furnace. The equipment and procedure are described and details of tensile, shear and impact tests are presented. Examples of the application of the process to the fabrication of turbine parts are given.

FLAME HARDENING

1681. SCHEVO, B. A. and FABRYKOWSKI, Z. J.
Flame hardening turret-ring ball races.
We.ding J., vol. 31, 1952, Aug., pp. 699-703

Describes the fixtures and procedures used for flame hardening ball races of turret rings over 6 ft. in diameter for armoured vehicles. It is claimed that this method is applicable to rings and races used for other purposes.

FLAME STRAIGHTENING

1682. HARRISON, H. L.
Straightening structural members in place.
We.ding J., vol. 31, 1952, May, suppl., pp. 257-262

The basic techniques used in straightening structural members are described and an illustration of their application to a damaged bridge is given. Laboratory experiments on straightening members under load were carried out and a suggested procedure for straightening structural members in situ, based on the results of these investigations and practical experience, is outlined.

GAS CUTTING

1683. ANON.
Electronically-controlled cutting head.
Engineering, vol. 174, 1952, Aug. 29, pp. 284-285
Describes the principle of the electronically-controlled cutting head for oxygen cutting machines. The tracing head operates from a black and white drawing, which is made slightly larger than the finished part to allow for the width of the cut, and is accurate to within 0.025 in.

PRESSURE WELDING

1684. TYLECOTE, R. F.
Pressure welding.
Metal Ind., vol. 81, 1952, July 18, pp. 43-46; July 25, pp. 72-73
In Part 1 the physical principles of pressure welding are considered and it is noted that the main function of the pressure is to increase the area of contact between the pieces to be welded. The effect of surface films of oxides, sulphides or grease and the methods for breaking them down are described. The weldability of the following materials is discussed and the effect of welding temperature and time are reviewed: indium, lead, tin, aluminium, gold, silver, copper, nickel and iron. In Part 2 the technique for making lap joints in aluminium sheet and butt joints in bars and sections, including notes on cleaning procedure, is given.

RESISTANCE WELDING

1685. HARKINS, F. G.
Process control for resistance welding under government specifications.
Welding J., vol. 31, 1952, July, pp. 567-574
American government specifications dealing with the resistance welding of various materials including nickel and cobalt base alloys and the light alloys contain instructions for process control and this article describes the system which has been developed to ensure the production and maintenance of high quality welding. A considerable number of tension, shear and macro-etch tests were carried out on specimens welded by fifteen different machines and the data obtained has enabled a relationship between nugget diameter and tension-shear value to be established. The macro-etch test was found to be superior to the tension shear test for welds which are to be subjected to high temperature or fatigue conditions in service.

RESISTANCE WELDING.—Control

1686. JOHNSON, I. W.
Slope taper control in spot welding 24ST aluminium.
Welding J., vol. 31, 1952, July, pp. 547-551
The addition of an after-weld current taper control to spot welding machines equipped with pre-weld slope control is claimed to produce crack free spot welds in Type 24ST aluminium alloy using single phase equipment without forging pressure. A lower electrode force than that normally recommended results in a smaller current demand and a low inertia head is not essential. Equipment faults such as tip skidding do not affect the quality of the weld. A test run on 0.032, 0.064 and 0.081 in. sheet is described and details of the equipment employed, material cleaning procedure and weld quality tests are given.

1687. KEMP, R. E.
Production welding 24ST3 aluminium using slope control.
Welding J., vol. 31, 1952, July, pp. 586-591
A practical article on the spot welding of 24ST3 aluminium on a single phase machine using slope control. Details of cleaning and welding procedure used in a series of tests are given, from the results of which it is concluded that the welds satisfy U.S.A. Government specifications, the cleaning methods described produce consistent surface resistances, maintenance costs are reduced with the single phase equipment and less experienced operators are required.

RESISTANCE WELDING.—Spot and Seam

1688. FULLERTON, J. R.
Problems and equipment in aircraft spot welding.
Welding J., vol. 31, 1952, July, pp. 536-541
Improvements in resistance welding equipment and technique have resulted in its adoption for the fabrication of the primary structures of aircraft. Materials considered in this article are the corrosion and heat resistant alloys and the light alloys. The applications, limitations and advantages of the following types of spot welding machines are noted: three phase frequency convertor, three phase electrostatic stored energy, three phase dry disc rectifier, and single phase alternating current machines. The importance of slope, pre- and post-heat controls, accurate pressure control and reduced heat for the first spot weld are emphasized.

1689. LEPITO, T. J. and TAYLOR, R. M.
Resistance welding quality control.
Welding J., vol. 31, 1952, Aug., pp. 692-698
The authors describe procedures to be adopted to ensure the maintenance of weld quality in the fabrication of parts for jet engines. Firstly, surface finish, chemical analysis and thickness of stock must be held within specified limits and secondly, the machine must be capable of producing consistent results. Seam and spot welding machine qualification tests are described and macrographs and radiographs of acceptable and unacceptable welds are shown. Recommended procedures for production quality control are given.

1690. NIPPES, E. F. and GERKEN, M.
Seam welding of 0.005 in. Inconel sheet.
Welding J., vol. 31, 1952, Aug. Supp., pp. 366-370
A certain job called for the seam welding of two thicknesses of 0.005 in. Inconel sheet. The welding equipment available was not suitable to requirements so a special machine with a low inertia head was constructed. Details of this machine are contained in an appendix. An investigation was then carried out with both annealed and ¼ hard material from which it is concluded that satisfactory results are obtainable with this alloy in both conditions. In each case the following technique was developed: current time—½ cycle "on", 4 cycles "off"; number of welds per inch—40; frequency of supply—60 cycles. For the annealed sheet the optimum current was 1,400 amps. and the electrode force 75 lb. and for the ¼ hard material these values were 1,300 amps. and 95 lb. respectively. Photomicrographs of the welds are shown.

TESTING.—Fluorescent Ink

1691. ANON.
Fluorescent ink as an inspection tool.
Light Metals, vol. 15, 1952, July, pp. 234-235
By dipping an object in fluorescent ink, wiping off the excess solution on the surface and allowing it to dry, exposing it to a source of ultra-violet light, surface cracks are easily detected by the green fluorescent of the ink contained in them.

WELDABILITY.—Ferrous.—Alloy Steels

1692. BIBBER, L. C., HODGE, J. M., ALTMAN, R. C. and DOTY, W. D.
A new high-yield-strength alloy steel for welded structures.
Welding Res. Council Bull., No. 13, 1952, July, pp. 1-17
This article concerns a new steel developed in the U.S.A. which has a yield strength of 100,000 lb. per sq. in. and retains its toughness at far lower temperatures than ordinary structural steels. It has excellent weldability and welds which develop the full strength of the base metal can be made without pre- or post-heat treatment. The development, metallurgical characteristics, welding and gas cutting properties, low temperature toughness, and applications of the steel are described.

WELDABILITY.—Ferrous.—Heat Resisting Steels

1693. BUCKLE, K. L.
High-temperature alloys in relation to gas-turbine design.
Proc. Inst. Mech. Engrs., vol. 166, No. 1, 1952, pp. 123-130
In order to achieve a thermal efficiency in the gas turbine comparable with that realized in steam practice, a higher turbine-entry temperature is necessary. Limiting discussion to the combustion and expansion sections of the gas turbine, the article first indicates that the use of metals in high temperature and stress conditions necessitates a new approach to component design. The phenomena of creep and fatigue assume major importance whilst pure temperature effects, such as expansion and thermal shock, are additional problems. These properties are defined and an indication is given of their significance in the design of combustion chambers, turbine wheels and blades. Susceptibility to heat treatment, intended to induce the desired high-temperature properties, is another important factor to be considered in material selection, as are fabrication characteristics. Since the latter govern both detail and general design, the merits of forging, casting and welding are outlined when applied to high-

temperature alloys. The paper concludes with a survey of the problems likely to be encountered with future materials, particularly ceramics, whilst suggesting that increased efficiency may be obtained by further research on established alloys or by design innovations such as cooling. (Author's abstract).

1694. CRANCHER, D. W.
Steam pipe materials for advanced steam conditions.
Trans. Inst. Marine Engrs., vol. 64, 1952, July, pp. 147-157

The trend towards high steam temperatures and pressures for ships' machinery introduces new problems regarding the choice of suitable materials and this article provides a survey of suitable materials for steam pipes working at these advanced steam conditions. The choice of a material depends upon the working temperature, but four available steels are described which cover a range of temperatures up to 1,050° F. These are plain carbon steel and three low alloy steels containing molybdenum, chromium and vanadium; they have all been used for steam pipes and represent British practice. The main requirements of a steel for high temperatures are resistance to creep and corrosion, stability of the microstructure and suitability for manufacture and welding. All these points are discussed in the paper and recommendations are given, based upon these properties, for the appropriate temperature range for each steel. There is an appendix giving notes on the creep of metals and creep testing. (Author's Abstract).

1695. TREMLETT, H. F.
Welding of heat-resistant steels.
Welding & Metal Fab., vol. 20, 1952, July, pp. 258-261; Aug., pp. 299-303

The author discusses various aspects of heat resistant steels as they affect the engineer. The question of resistance to scaling is considered and also the effect of alloying elements such as chromium, nickel, and titanium upon the properties of the steels concerned. Problems arising when welding heat-resisting steels are dealt with and certain precautions advocated. (Author's Abstract).

WELDABILITY.—Ferrous.—High Tensile Steels

1696. SMITH, D. W., WHITMAN, J. G. and COTTRELL, C. L. M.
Stress-strain relationship of a high-tensile weldable structural steel.
Metallurgia, vol. 45, 1952, Apr., pp. 169-172

In order to save weight in the construction of a prefabricated transportable bridge, a straight carbon manganese steel was replaced by a low-carbon manganese molybdenum steel, but the expected advantages of using such a steel were not realised due to the low limit of proportionality exhibited. Considerable improvement could be effected by tempering at 600° C. (Authors' abstract).

WELDABILITY.—Ferrous.—Stainless Steel

1697. LINNERT, G. E.
17 Cr stainless replaces 18-8 in many weldments.
Iron Age, vol. 170, 1952, June 26, pp. 97-100; July 3, pp. 123-132

If correct procedures are employed the corrosion resistance of 17 per cent. chromium stainless steel is equal to that of 18-8. The 17 per cent. chromium type stabilized with titanium is easier to fabricate than the straight grade and distorts less during welding than the 18-8. Gas welding should not be used on types 430 or 430T stainless as grain growth and/or carbon pickup may occur. Arc welding prevents loss of titanium on 430T. Preheating when using 430 electrodes minimizes the pinhole conditions sometimes encountered. When spot welding cross wire joints a mutual indention of from 20 to 30 per cent of the wire diameter is used and the correct current from 1 to 10 cycles in duration is then selected.

1698. THIELSCH, H.
Stainless-steel applied liners.
Welding J., vol. 31, 1952, July Supp., pp. 321-337

A review of published and unpublished information on the welding processes used in the application of corrosion and heat resistant liners to mild and low alloy steels. The processes considered are spot and seam welding, plug welding, strip welding and through welding and heat treatments in accordance with the A.S.M.E. requirements are covered. Various testing procedures are described and a bibliography of 68 references is appended.

WELDABILITY.—Non Ferrous.—Clad Metals

1699. ANON.
Copper clad aluminium.
Metal Ind., vol. 81, 1952, Aug. 29, pp. 163-165

This article deals with the physical and chemical properties and the applications of copper clad aluminium and it is noted that it may be spot welded with care and soldered readily.

WELDABILITY.—Non Ferrous.—Copper

1700. BERNHARDT, L.
Forming copper prior to assembly.
Welding & Metal Fab., vol. 20, 1952, Aug., pp. 281-285; Sept., pp. 316-320

In Part 1 the mechanical and physical properties of copper and some of its alloys in sheet and strip form are considered. Various factors in die design for blanking operations are noted and in certain circumstances tolerances closer than 0.001 in. are obtainable. Deep drawing and pressing procedures are described and recommended annealing treatments given. In Part 2 bending, folding and seaming are covered, reference being made to the horn type lock seaming tool. It is noted that spinning still remains essentially a craft and this is also true of the forming of thick copper plate. The article concludes with brief notes on the gas, arc, resistance and pressure welding processes, brazing and soldering.

WELDABILITY.—Non Ferrous.—Lead

1701. ANON.
Lead welded by inert-gas-shielded arc process.
Materials & Methods, vol. 36, 1952, July, p. 97

It is claimed that joining lead by the inert-gas-shielded metal arc process is considerably faster than soldering. Welding speeds of 30 in. per minute at 50 amps. are used, but it is necessary to take precautions against the inhalation of the toxic lead fumes.

WELDABILITY.—Non Ferrous.—Molybdenum

1702. BOAM, W. M.
Jet engines push welded molybdenum study.
Iron Age, vol. 170, 1952, July 10, pp. 145-148

The high thermal conductivity and high melting temperature of molybdenum (4,750° F.) make this material potentially suitable for high temperature service in gas turbines and ramjet engines. Considerable difficulties are being experienced in the fabrication of this material and welds that give ductility at room temperature have not yet been accomplished. At 400° F., however, the ductility of the joints is appreciable. For the production of sound welds the molten metal must be shielded from air and other sources of oxygen and for this reason inert-gas-shielded metal arc welding is necessary. Molybdenum alloys can be used in the 3,000° F. range if the stresses are not high. Poor oxidation resistance at these temperatures necessitates the application of a special coating to the molybdenum. Various problems requiring further research are indicated and it is noted in conclusion that the attainment of ductile welds consistently appears to be controlled as much by manufacturing technique as by welding procedure.

WELDED CONSTRUCTION

1703. ANON.
Heavy construction at Thorncliffe.
Welding & Metal Fab., vol. 20, 1952, Sept., pp. 310-315

Following a brief note on shop equipment and organization the fabrication of a typical product of these works, an ingot casting car, is described. Details of welding procedure and jigging and manipulating equipment are given and a typical procedure chart for erection and welding is shown.

WELDED CONSTRUCTION.—Buildings

1704. ANON.
B.W.R.A. fatigue testing laboratory.
Welding & Metal Fab., vol. 20, 1952, Aug., pp. 289-292

A short article on the new laboratory of the B.W.R.A. with notes on current research and future work, the laboratory equipment and the structural design of the building, which is the first practical application of the plastic theory.

WELDED CONSTRUCTION.—Design

1705. FRANCK, R. J.

When to design for cast-welded construction.

Welding Eng., vol. 37, 1952, July, p. 43

A short article intended to act as a guide to the substitution of composite structures formed of castings and fabricated sections for intricate castings. As an illustration the re-design of a drive spacer required in five different lengths is taken and it is shown how all sizes may be produced from two simple standard castings and steel tube.

1706. RODERICK, J. W. and HEYMAN, J.

Extension of the simple plastic theory to take account of the strain-hardening range.

Inst. Mech. Engrs., Applied Mech., Proc., vol. 165, 1951, pp. 189-197

The assumption in the simple plastic theory that strain can increase indefinitely after yielding is satisfactory for the low carbon steels which have a plastic range 8-10 times the strain at yield, but it is necessary to consider the effect of strain hardening for stronger steels where the plastic range is relatively short. Four steels varying in carbon content from 0.28 per cent. to 0.89 per cent. were tested and the results of these tests described in this article give good support to the theoretical work presented.

WELDED CONSTRUCTION.—Machinery

1707. BONDY, O.

Welded machine tools.

Engineers Digest, vol. 13, 1952, Aug., pp. 263-266

The author outlines the advantages of welded construction for machine tools, but quotes a reference stating that Great Britain uses a higher percentage of iron castings than either Europe or the U.S.A. Various fabricated machine tools are shown and it is noted that the use of welded construction in this field is likely to increase.

WELDED CONSTRUCTION.—Pressure Vessels

1708. JOHANNESEN, J. K.

Pressure vessel conversion.

Welding & Metal Fab., vol. 20, 1952, Sept., pp. 321-324

Describes how a Lancashire boiler shell and a large pressure vessel were cut and converted into three pressure vessels for a special purpose. Details of welding procedure are given.

WELDED CONSTRUCTION.—Railway Rolling Stock

1709. NEWELL, J. C.

Welding of locomotive frames and boiler fireboxes.

New Zealand Eng., vol. 7, 1952, June 15, pp. 242-244

A practical article describing first the repair of cracks in locomotives main frames and secondly, repairs to fireboxes.

CLASSIFIED ADVERTISEMENTS

WELDING ENGINEER, 41, A.M.Inst.W.

Seeks executive/administrative post, home or abroad, where extensive managerial experience—training, construction, maintenance, oil field—can be used profitably. Stores control, design, procedure, production.—Box 102.

RADIOGRAPHER (X- and Gamma-Ray) with experience of magnetic crack detection method, seeks post. Considerable experience as welding supervisor in structural and pressure work, etc.—Box 101.

ELMET WELDING MATERIALS

COPELMET
(COPPER-TUNGSTEN)

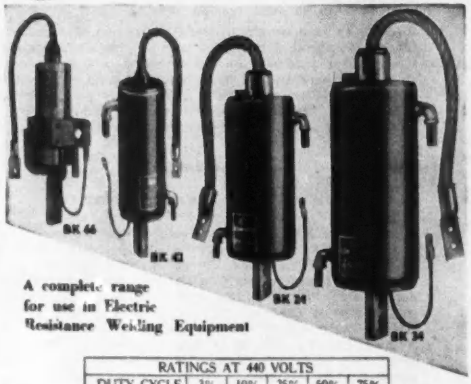
COPELMET-faced dies give the LONGEST LIFE in FLASH WELDING as well as in PROJECTION WELDING, UPSETTING and as inserts in SPOT & SEAM WELDING ELECTRODES and JIGS

Copelmet is one of the ELMET range of materials made specially for high performance Resistance Welding Electrodes.

FULL PARTICULARS ON REQUEST

METRO-CUTANIT LTD
ASSOCIATED WITH METROPOLITAN-VICKERS ELECTRICAL CO LTD
160 PICCADILLY LONDON W1
Telephone: GROSVENOR 7121

B T-H IGNITRONS
—HIGH-SPEED HEAVY-CURRENT ELECTRONIC "CONTACTORS"



A complete range for use in Electric Resistance Welding Equipment

RATINGS AT 440 VOLTS					
DUTY CYCLE	3%	10%	25%	50%	75%
IGNITRONS	kVA	kVA	kVA	kVA	kVA
TWO BK 66	300	158	88	44	28
TWO BK 42	600	361	202	110	73
TWO BK 24	1,200	836	475	268	176
TWO BK 34	2,400	1,976	1,100	691	440

Interchangeable with American Ignitrons sizes A B C D without modification to your equipment.

THE BRITISH THOMSON-HOUSTON COMPANY LIMITED RUGBY ENGLAND
Member of the AEI group of companies

BETTER WELDS at lower cost

FAR LESS TIME AND MATERIALS REQUIRED

Much of the advantage gained by the use of high quality welding equipment can be thrown away—unless you also use top-grade rods and fluxes. ALDA rods and fluxes are the finest you can get. They include only those materials prepared to the formulæ of B.O.C metallurgists, or those proved by repeated tests to fulfil their specific purpose. All consignments are analysed before issue. As a result, you can rely on ALDA rods and fluxes every time—for better welds, made more quickly, and with the minimum consumption of essential materials. Use ALDA rods and fluxes—and *get* efficiency with economy.

FREE

. . . and very useful indeed!

The comprehensive Welding Guide and ALDA Data Sheet provides a list of 54 different rods and 21 different fluxes with full details of their applications and characteristics.
Also: Six different methods of removing flux residue, according to the types of metal involved.

WRITE NOW TO YOUR LOCAL B.O.C BRANCH FOR YOUR COPY

ALDA
WELDING RODS AND FLUXES

BOC **THE BRITISH OXYGEN CO LTD**

LONDON AND BRANCHES

APPLEBY PLATES

for welding

Whether it be for bridges and other structures, for storage tanks, gas-holders, or for Class 1 pressure vessels and boiler drums, welded construction has "come to stay," on account of its economy of material, tightness of joints, and the neat sound job which welding makes.

Appleby Steel Plates have excellent physical properties, are ductile, flat, well-sheared, and will be found highly suitable to all forms of welded construction in which plates are used.

THE UNITED STEEL COMPANIES LTD

APPLEBY-FRODINGHAM STEEL COMPANY · SCUNTHORPE · LINCS

BRANCH OF THE UNITED STEEL COMPANIES LIMITED

TELEPHONE: SCUNTHORPE 3411 (9 LINES) TELEGRAMS: "APFROD" SCUNTHORPE

AF.67

THE VERSATILE FUEL GAS

For Cutting • Heating • Metal Spraying • Brazing

PYROGAS

BRITISH CUTTING GASES LTD.,

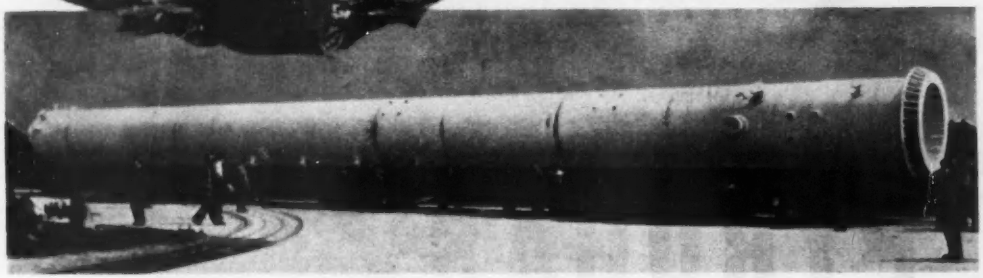
Head Office: Downshire House, Roehampton Lane, London, S.W.15. Putney 7742. Pyrogas, Put, London

Branches: BIRMINGHAM, GLASGOW, LONDON (56, Lymington Road, N.W.6), LYMINGTON (Hants), MANCHESTER SUNDERLAND, SHEFFIELD, THORNABY-ON-TEES.

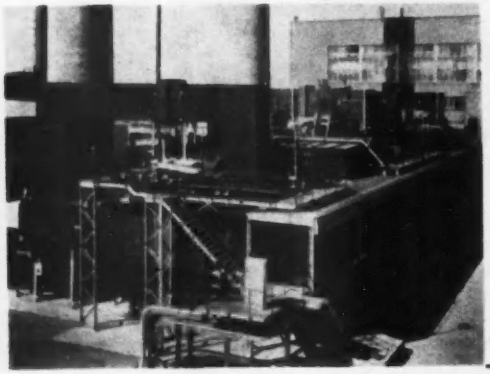
BABCOCK

Equipment for the Oil Industry

The illustrations show (LEFT and BELOW) typical welded treating towers manufactured by Babcock & Wilcox Ltd. for new oil refineries in Britain. (BOTTOM LEFT) Typical boiler installation, in a European oil refinery, comprising four BABCOCK oil-fired Integral Furnace boilers (each for 75,000 lb. of steam per hour) in a self-contained outdoor arrangement, requiring no boiler house.



BABCOCK & WILCOX LTD. are manufacturers of a wide range of *boilers*, *welded pressure vessels*, *heat-exchangers* and *waste-heat utilisation plant*, and have extensive experience in the manufacture of such plant for the oil industry. Pioneers in the manufacture of fusion-welded pressure vessels, they have made thousands of these, up to the largest sizes and for the highest pressures; while in the field of steam-raising, they bring to each installation an experience of over 75 years and the reputation of the world's leading, and largest, boilermakers.



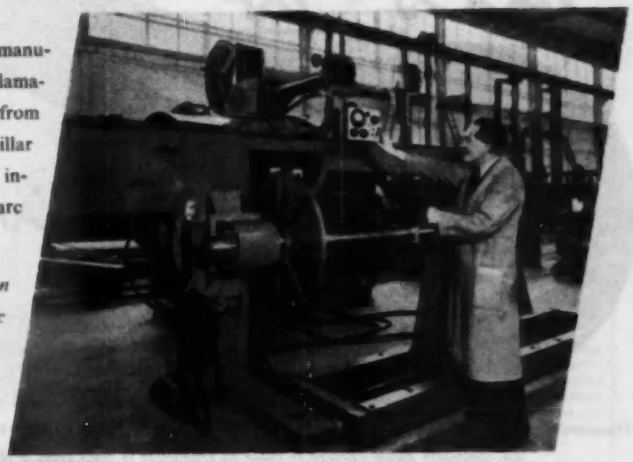
BABCOCK & WILCOX LTD

BABCOCK HOUSE, FARRINGDON ST. LONDON, E.C.4

FUSARC *Welding Machine Tools*

This machine designed and manufactured by Fusarc for the reclamation of worn components from railway rolling stock and caterpillar tractors is typical of the many installations produced by Fusarc during recent years.

Fusarc Welding Machine Tools can now be supplied with either the Fusarc visible arc process or Unionmelt submerged arc process, both the first in their particular field of application.



UNIONMELT TRADE MARK AUTOMATIC SUBMERGED ARC WELDING

Fusarc AUTOMATIC VISIBLE ARC WELDING

Are you on our mailing list?

We specialise in the design and manufacture of automatic fusion welding equipment for all branches of the welding industry, and detailed News Bulletins describing each equipment are issued at regular intervals.

We shall be pleased to add your name to our mailing list.

FUSARC LTD., Team Valley, Gateshead, 11, Co. Durham

Dairy Milk in welded tanks

A considerable portion of the stainless steel equipment produced by Butterfields is for the food industry, in one branch or other. The trio of stainless steel welded tanks illustrated hold 600 gallons of milk each. Quite likely you will taste some of this milk, not in your tea, but in your chocolate ration.

Butterfield fabrications are produced to the highest engineering standards, not least in the quality of welding.

BUTTERFIELD

STAINLESS STEEL EQUIPMENT

For transporting bulk fluids by road, Butterfield Road Tanks are famous for their ability for "keeping going" and keeping on.

W. P. BUTTERFIELD, SHIPLEY, YORKS.
Tel. 52244 (7 lines)

LONDON: Africa House, Kingsway, W.C.2
Tel.: HOLborn 1449

It's all the same to HANCOCK oxygen cutting machines.
The accuracy and efficiency of HANCOCK profilers is such that they, and they alone, can precision cut these exacting sharp corners and small radius circles.
There are three standard types of machines in ten different sizes, each with six alternative drives, but special profilers are constantly being designed to speed up production in many types of industry. If you have a cutting problem, tell us about it—*remember Hancoxygen cutting is best.*

HANCOCK & CO. (Engineers) LTD.
PROGRESS WAY, CROYDON, ENGLAND. Telephone: CROYDON 1908 (PBX). Telegrams: Hanco, Phone Croydon

HANCOCK CUTTING MACHINES

ALICRAFT
HARDCRAFT
STEELCRAFT
FERROCRAFT
BRONZECRAFT
for craftsmen who want the best
Here is an outstandingly good range of oxy-acetylene Welding Rods—ALIcraft for aluminium and alloys, HARDcraft for hard surfacing, STEELcraft for mild steel and iron, BRONZEcraft for bronze-welding. They will give you consistently reliable welds.
Full details and prices are available on request.
WELDCRAFT LTD
PROGRESS WAY · CROYDON · ENGLAND Phone: CROydon 1908 (PBX)

Photograph by courtesy of Bartram & Sons Ltd.

Pressed Steel Troughing is used by the leading Shipbuilders in the Tyneside and Clydeside areas.

EGYPT—
The Port Said Engineering Works, Port Said

Large illustration: TRANSVERSE BULKHEAD IN POSITION

Small illustration: BULKHEADS WITH GIRDERS AND WEBS ATTACHED READY FOR ERECTION.

PRESSED STEEL

Troughing

FOR SHIPS' BULKHEADS

Sections of Troughing pressed from Steel Plates are found in actual practice to be superior to the old method of welding steel plates together. Here are six specific advantages:—

● Saves up to 20% steel weight. ● Reduces labour costs. ● No comparative sharp corners to damage cargo. ● Fewer edges where corrosion can begin. ● Smooth surface throughout which is easy to clean, scrape and paint. ● Suitable for transverse, longitudinal and 'tween-deck bulkheads.

Troughing is supplied in lengths up to 30 feet.

MOTHERWELL BRIDGE & ENGINEERING CO. LTD.

Telegrams: BRIDGE, MOTHERWELL
Telephone: MOTHERWELL 40, 41, 42

HEAD OFFICE AND WORKS:
MOTHERWELL

London Address: 82, VICTORIA STREET, S.W.1
Telegrams: HOBRICOLIM, SOUWEST, LONDON
Telephone: VICTORIA 4183

RESEARCH . . .
the Key to Efficiency -

Increased productivity is a first fruit of Research. Without it productivity becomes static, invention is stultified, the industrial race is lost. The Quasi-Arc Company has enjoyed 40 years pre-eminence in Electric Arc Welding, but without a highly qualified research staff constantly at work could not hope to maintain its position in the industry. Q.A. manufacture 31 different types of electrodes, design a large range of arc welding plant, and are sole concessionaires for the newly developed 'Twin-Arc' welding process.

A comprehensive catalogue is available on request

Quasi-Arc

THE QUASI-ARC COMPANY LIMITED
BILSTON, STAFFORDSHIRE

Manufacturers of Electrodes, Plant and Accessories for Manual Arc Welding.

'Man at the helm'

When you think of control...

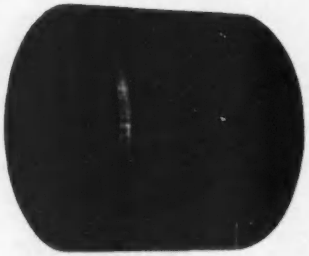
He may not be a professor, brilliant scientist or mathematician, yet miles from anywhere, the man at the helm has perfect control over the course of his ship. Likewise a man using compressed gas Regulators must have perfect control at his command, so . . .

...think of **REGULATORS** *by* B·I·G

BRITISH INDUSTRIAL GASES LTD.
Head Office: 32 VICTORIA STREET, LONDON, S.W.1
Telephone: ABBey 6082/3 and 4

WORKS			
	London:	Eastway, Hackney, London, E.9	Telephone: Amherst 5443/4
	Manchester:	Richmond Road, Trafford Park, Manchester, 17	Telephone: Trafford Park 1041/2
	Liverpool:	Fleming Road, Speke, Liverpool, 19	Telephone: Hunts Cross 1212/3
	Glasgow:	Queen Elizabeth Ave., Hillington, Glasgow, S.W.2	Telephone: Halfway 1651

Example of work done by the "INCANTO"
OXY-ACETYLENE
TUBE CUTTING AND END BEVELLING MACHINE



Straight or Bevel Cuts on Tubes up to 12"

Full particulars on application to

THORN & HODDLE LTD.,
151, VICTORIA STREET, LONDON, S.W.1
Telephone: VICTORIA 3373 Telegrams: INCANTO, SOWEST, LONDON

SIFBRONZE

This is the welding rod for all round service. It requires little or no preheating and can be used to weld all metals except aluminium. Sifbronze patented copper-zinc alloy rods are better because of their EXTRA constituents.

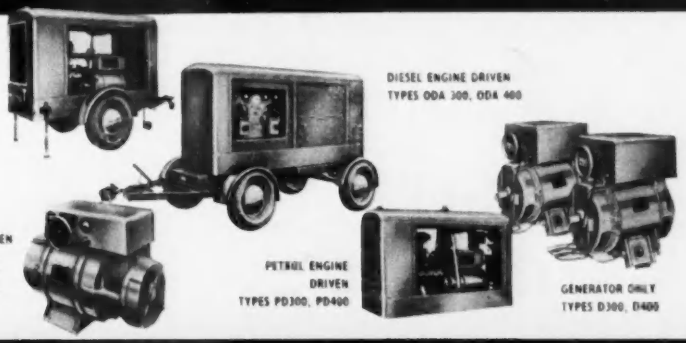
Write for full details today, also ask for free copy of "Sif-Tips" magazine.

SUFFOLK IRON FOUNDRY (1920) LTD
SIFBRONZE WORKS, STOWMARKET, SUFFOLK
Telephone Stowmarket 183 (3 lines)

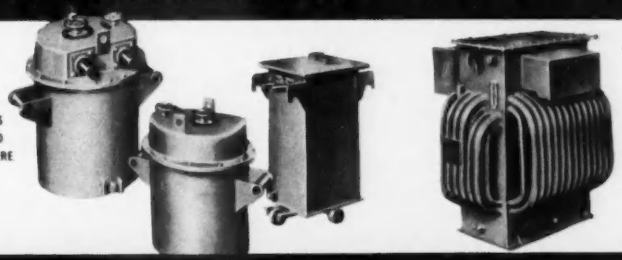
ROCKWELD

Arc welding electrodes for all purposes.
A.C. & D.C. welding plant of all types and capacities.
Welders' Accessories and general supplies for the welding shop.

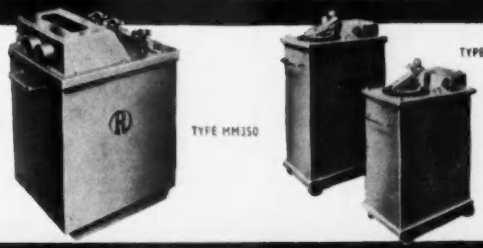
SINGLE-OPERATOR D.C. ARC WELDING PLANT


PETROL ENGINE DRIVEN TYPE PD250
DIESEL ENGINE DRIVEN TYPES ODA 300, ODA 400
A.C. MOTOR DRIVEN TYPES AD175 AD300 AD400
PETROL ENGINE DRIVEN TYPES PD300, PD400
GENERATOR ONLY TYPES D300, D400

MULTI-OPERATOR A.C. ARC WELDING PLANT



SINGLE-OPERATOR ARC WELDING TRANSFORMERS



Our Engineers are available for advice on the selection, arrangement and installation of these machines.

ROCKWELD LTD · CROYDON · SURREY TEL: CROYDON 7161 (5 LINES) GRAMS: ROCKWELD, PHONE, CROYDON

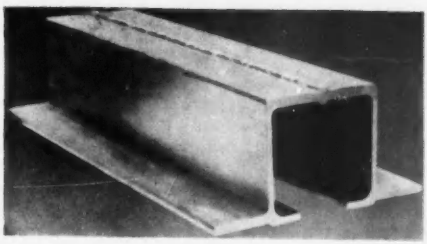
MUREX
ALUMINIUM 5% SILICON
EXTRUDED ELECTRODES

Officially approved for welding aluminium alloys by the deep penetration method . . .

Murex aluminium 5% silicon electrodes have been specially developed for the arc welding of aluminium alloys, in which they can produce welds having high tensile strength—minimum 10·5 tons/sq. in. The electrodes may be used for deep penetration welding with currents up to 400 amps. D.C. for welding sections of thicknesses up to ½ in. without special edge preparation and without preheating.

The electrodes are of the plain extruded type and have the advantages of uniformity of coating and welding properties. They are smooth running, simple to use and while they are designed for downhand welding, they can also be used in all positions. Another feature is that the slag is easy to remove.

The electrodes are officially approved by the Ministry of Supply for welding military bridging equipment and they represent the latest advance in the arc welding of aluminium alloys.



An aluminium alloy section of ½ in. thickness welded with one run and a sealing run, using a No. 4 gauge Murex extruded aluminium silicon electrode without special edge preparation and without preheating.

ADVANTAGES

- ★ *Officially approved by the Ministry of Supply for the welding of military bridging equipment.*
- ★ *High tensile strength welds—minimum 10·5 tons/sq. in.*
- ★ *For deep penetration welding—larger gauge electrodes can be used with currents up to 400 amps. D.C.*
- ★ *Aluminium alloys of thicknesses up to ½ in. can be welded without special edge preparation and without preheating.*
- ★ *Plain extruded type of electrode for uniformity of coating and welding properties.*
- ★ *Smooth running—simple to use—primarily a downhand electrode but can be used in all positions. Easy slag removal.*

ELECTRIC ARC WELDING MUREX EQUIPMENT & ELECTRODES

MUREX WELDING PROCESSES LIMITED, WALTHAM CROSS, HERTS. Telephone: WALTHAM CROSS 3636

T9

Printed in England by LAWRENCE PRESS LTD., Henry Road, New Barnet, Herts., and Published by The Institute of Welding, 2, Buckingham Palace Gardens, London, S.W.1. *October*, 1952.